Elective cancer surgery in COVID-19 free surgical pathways during the SARS-CoV-2 pandemic: An international, multi-centre, comparative cohort study

COVIDSurg Collaborative*

**A complete list of the investigators is included in Appendix A*

Corresponding author: Mr Aneel Bhangu, NIHR Global Health Research Unit on Global Surgery, Heritage Building, University of Birmingham, Mindelsohn Way, Birmingham, UK, B15 2TH. Correspondence to: A.A.Bhangu@bham.ac.uk. ORCID ID: 0000-0001-5999-4618

Keywords: Surgery; Surgical oncology; Cancer; COVID-19; SARS-Cov-2; Pulmonary complications

Word count: 2969 words

Abstract word count: 271 words

Running head: COVID-19 free surgical pathways

Role of the funding source: This report was funded by a National Institute for Health Research (NIHR) Global Health Research Unit Grant (NIHR 16.136.79) using UK aid from the UK Government to support global health research; Association of Coloproctology of Great Britain and Ireland; Bowel & Cancer Research; Bowel Disease Research Foundation; Association of Upper Gastrointestinal Surgeons; British Association of Surgical Oncology; British Gynaecological Cancer Society; European Society of Coloproctology; NIHR Academy; Sarcoma UK; Vascular Society for Great Britain and Ireland; Yorkshire Cancer Research. The funders had no role in study design, data collection, analysis and interpretation, or writing of this report. The views expressed are those of the authors and not necessarily those of the National Health Service, the NIHR, or the UK Department of Health and Social Care.

Data sharing: Data sharing requests will be considered by the management group upon written request to the corresponding author. If agreed, de-identified participant data will be available, subject to a data sharing agreement.

Presentations: This study has not previously been presented at an academic meeting or conference.

Context summary

Key objective: Patients that are infected with SARS-CoV-2 in the perioperative period are at high risk of pulmonary complications and death. Health systems have begun to create COVID-19 free surgical pathways in both separate elective hospitals and major acute hospitals, in which elective operating room, critical care and inpatient ward areas are not shared with COVID-19 patients. Major service redesign to provide these pathways is expensive and difficult; data are urgently needed to inform clinical practice.

Knowledge generated: Our data demonstrated that postoperative pulmonary complication rates, SARS-CoV-2 infection rates, and mortality rates were consistency lower for patient within COVID-19 free surgical pathways than in hospitals with no defined pathway. These findings persisted after risk-adjustment, sensitivity analyses of low risk patients and propensity score matched groups, and in patients who had a negative preoperative SARS-CoV-2 test. Differences in outcomes were observed in areas with both high and low incidence of SARS-CoV-2.

Relevance: As health providers restart elective cancer surgery, they must prevent harm to cancer patients by investing in dedicated COVID-19 free surgical pathways.

Summary

Purpose: As cancer surgery restarts following the first COVID-19 wave, healthcare providers urgently require data to determine where elective surgery is best performed. This study aimed to determine whether COVID-19 free surgical pathways were associated with lower postoperative pulmonary complication rates than in hospitals with no defined pathway.

Patients & methods: This international multicentre cohort study included patients undergoing elective surgery for 10 solid cancer types, without preoperative suspicion of SARS-CoV-2. Participating hospitals included patients from local emergence of SARS-CoV-2 until 19 April 2020. At the time of surgery, hospitals were defined as having a COVID-19 free surgical pathway (complete segregation of the operating theatre, critical care and inpatient ward areas) or no defined pathway (incomplete or no segregation, areas shared with COVID-19 patients). The primary outcome was 30-day postoperative pulmonary complications (pneumonia, ARDS, unexpected ventilation).

Results: Of 9171 patients from 447 hospitals in 55 countries, 2481 were operated in COVID-19 free surgical pathways. Patients undergoing surgery within COVID-19 free surgical pathways were younger and less comorbid than those in hospitals with no defined pathway, but with similar proportions of major surgery. After adjustment, pulmonary complication rates were lower with COVID-19 free surgical pathways (2.2% versus 4.9%, adjusted odds ratio 0.62 [0.44 to 0.86]). This was consistent in sensitivity analyses for low-risk patients (ASA grade 1/2), propensity-score matched models, and patients with negative SARS-CoV-2 preoperative tests. The postoperative SARS-CoV-2 infection rate was also lower in COVID-19 free surgical pathways (2.1% versus 3.6%; adjusted odds ratio 0.53 [0.36 to 0.76]).

Conclusion: Dedicated COVID-19 free surgical pathways should be established to provide safe elective cancer surgery during current and before future SARS-CoV-2 outbreaks.

Introduction

During the initial phases of the SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) pandemic, an estimated 2.3 million cancer operations worldwide were postponed due to the risk of in-hospital transmission [1]. Perioperative SARS-CoV-2 is associated with high risk of pulmonary complications and death [2-5]. Elective surgical activity was reduced to increase critical care capacity for COVID-19 (coronavirus disease 2019) patients, and to release surgical team members to support wider hospital responses [6-8]. However, some elective surgery for time-sensitive conditions continued, prioritising patients with resectable cancers at risk of progression and patients for whom alternative treatment modalities would be ineffective [9-11].

Before the pandemic, most cancer surgery was performed in hospitals that also supported acute medical services [12-14]. Such hospitals have admitted COVID-19 patients during the pandemic, increasing the risk of cross-infection of elective surgery patients. To avoid this, some healthcare providers have established dedicated COVID-19 free surgical pathways, which deliver surgery, critical care and inpatient ward care with no shared areas with COVID-19 patients.

Major reorganisation of hospital services to provide COVID-19 free surgical pathways for elective cancer surgery needs to be justified, as it will carry significant costs for providers and patients. Information is urgently required to determine whether these pathways reduce adverse postoperative outcomes. This study aimed to compare the rate of postoperative pulmonary complications after elective cancer operations in COVID-19 free surgical pathways and hospitals with no defined pathway.

Methods

Study design and protocol

This was an international multicentre cohort study of adults undergoing elective cancer surgery. Local Principal Investigators were responsible for obtaining clinical audit, institutional review or ethical board approval in line with local and national regulations. Data were collected online and stored on a secure data server running the Research Electronic Data Capture (REDCap) web application [15].

Centres and settings

Hospitals performing elective cancer surgery in areas affected by the COVID-19 pandemic were eligible to participate. Enrolment of consecutive patients commenced from the date of admission of the first SARS-CoV-2 infected patient to the participating hospital or, in the case of COVID-19 free surgical pathways in hospitals where no cases had been recorded, to the nearest hospital treating COVID-19 patients.

Each patient was classified as undergoing surgery within a COVID-19 free surgical pathway or with no defined pathway. In order to determine whether a COVID-19 free surgical pathway was used, an assessment was made of the operating room, critical care, and inpatient ward areas where each patient was treated. Patients were classified as being treated within a COVID-19 free pathway if there was a policy of complete segregation in all three areas away from COVID-19 patients. Patients were classified as being treated within no defined pathway if in any one of these areas was shared with COVID-19 patients. The classification was based on whether there was a policy of segregation in place rather than whether individual elective patients came in to contact with COVID-19 patients, as asymptomatic SARS-CoV-2 infection is common, so contact with an infected patient was possible even if this was not known at the time. COVID-19 free surgical pathways could be provided by hospitals that only provided elective care, including specialised units set up during the pandemic. Alternatively, they could be provided by acute hospitals that designated separate

COVID-19 free areas and COVID-19 treatment areas, ensuring there were no shared areas. In any particular hospital, it was possible that some patients were treated within a COVID-19 free surgical pathway whereas others had no defined pathway (e.g. where a COVID-19 free surgical pathway was introduced part way through the study inclusion period), and our patient-level classification captured this. *Figure 1* displays examples of COVID-19 free surgical pathways and hospitals with no defined pathways.

Surgical pathway components

In order to better understand health system responses to the COVID-19 pandemic, additional data points were introduced on 2 April 2020 to capture data on individual components of the surgical pathway (operating room, critical care, inpatient ward). These were completed for consecutive patients after this date.

Patients and procedures

Adult patients (18 years and over) undergoing elective surgery with curative intent for a suspected cancer were included from emergence of COVID-19 up to 19 April 2020. Patients were identified preoperatively from multidisciplinary team meeting (or tumour board) lists and the subsequent operation location identified by the operating surgeon. Patients were followed up to postoperative day 30, with the day of surgery being day zero. All consecutive patients undergoing eligible surgery were included (*Appendix B*). Eligible cancer included colorectal, oesophagogastric, head and neck (oral, oropharyngeal, laryngeal, hypopharyngeal, salivary, thyroid, paranasal sinus, skin), thoracic (lung, pleural, mediastinal, chest wall), hepatopancreatobiliary (liver, pancreatic), urological (prostate, bladder, renal), gynaecological (uterine, ovarian, cervical, vulval, vaginal), breast, sarcoma (soft-tissue, bony), and intracranial malignancies (*Appendix C*). Participating centres could contribute data for either single or multiple cancers dependent on local services and capacity [16].

Patients who had clinical symptoms consistent with COVID-19 or who were confirmed to have SARS-CoV-2 infection (by quantitative Reverse Transcription Polymerase Chain Reaction [RT-PCR]

and/or positive imaging by computed tomography (CT) thorax in the 72 hours before surgery) at the time of surgery were excluded.

Data variables

To account for different tumour grading and staging systems across solid cancers, disease status was classified as early stage (organ confined, non-nodal, non-metastatic, fully resectable) or advanced stage (growth beyond organ, nodal, metastatic operated with curative intent). Full definitions are shown in *Appendix C*. Grade of surgery was categorised based on the Clinical Coding & Schedule Development Group as either Minor (minor/intermediate) or Major (major/complex major) [17, 18]. Preoperative testing was defined as a swab test and/or CT thorax performed in the 72 hours before surgery in order to confirm SARS-CoV-2 status.

Outcome measures

The primary outcome measure was the rate of postoperative pulmonary complications within 30 days after surgery. This included pneumonia, acute respiratory distress syndrome (ARDS), and/or unexpected postoperative ventilation (*Appendix C*). The secondary outcomes were postoperative SARS-CoV-2 infection and mortality within 30 days after surgery. Postoperative SARS-CoV-2 infection was defined as a positive swab, positive CT thorax, or a clinical diagnosis of symptomatic COVID-19 in patients for whom a swab test and CT scan were unavailable.

Community SARS-CoV-2 incidence

The community SARS-CoV-2 incidence within each participating hospital's local community was extracted from World Health Organisation [21], European Centre for Disease Prevention and Control [22], or US Centre for Disease Control and Prevention (CDC) [23] statistics. SARS-CoV-2 incidence was calculated for two-week windows in March and April 2020 based upon the number of confirmed SARS-CoV-2 cases at the smallest available administrative level (city, region, or country) [24]. Hospitals were classified as being in communities with either low (<25 cases per 100,000

population) or high (≥25 cases per 100,000 population) SARS-CoV-2 incidence (*Supplementary Table 1*).

Data integrity

Previous international outcomes studies have achieved greater than 95% case ascertainment and greater than 98% data accuracy during external validation [25]. We identified low volume centres (pre-defined as ≤5 patients per participating specialty) and asked local Principal Investigators to confirm case ascertainment against MDT records. If a specialty within a hospital was found to have incomplete case ascertainment any data entered from this specialty were excluded from analysis.

Statistical analysis

The study was conducted according to STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) [26] and reported according to SAMPL (Statistical Analyses and Methods in the Published Literature) [27]. Non-parametric data were summarised with medians and interquartile ranges and differences between groups were tested using the Mann-Whitney U test. The $\chi 2$ test was used for categorical data. Missing data were included in flowcharts and summary tables, allowing denominators to remain consistent in calculations.

Bayesian univariable and multivariable mixed effects logistic regression was used to calculate odds ratios and 95% credible intervals (C.I.). Clinically plausible patient, disease, operation and location specific factors were selected a priori for inclusion in adjusted analyses, in order to identify independent predictors of postoperative pulmonary complications (primary outcome). Country was included as a random effect in both the unadjusted and adjusted models. An exploratory analysis was conducted of the association between components of the COVID-19 free surgical pathway and the primary outcome measure. Analyses were carried out using the R Foundation Statistical Program version 3.1.1 (packages: finalfit, tidyverse, BRMS) [28] (*Appendix D*).

Sensitivity analyses

We anticipated a selection bias, with lower risk patients being more likely to be treated within COVID-19 free surgical pathways. To account for this risk of bias, we: (1) explored differences in the postoperative pulmonary complications stratified by three common risk factors (age, sex, and ASA grade); (2) performed an sensitivity analysis for pulmonary complications including low risk (ASA grade 1 or 2) patients only (3) performed propensity score matching using a nearest-neighbour method including patients within COVID-19 free surgical pathways in a 1:1 ratio with those with no defined pathway (*Appendix D*).

In order to exclude a potential confounding effect of pre-symptomatic carriage of SARS-CoV-2 in the association between hospital type and the primary outcome, we performed a further sensitivity analysis including only patients with a negative preoperative SARS-CoV-2 swab test.

Results

Patients and procedures

At the time of this analysis (June 15, 2020), a total 9171 patients from 447 hospitals were included. These patients were from the United Kingdom (29.2%, 2679 patients), Italy (17.3%, 1583), Spain (8.3%, 764), United States (6.3%, 574), and a further 51 countries. Overall, 39.2% (3698) of patients were male, 17.9% (1644) were aged under 50 years, and 8.3% (761) were aged 80 years or over. Complete baseline patient, disease, and operative characteristics are displayed in Table 1.

27.1% (2481) of patients were operated within COVID-19 free surgical pathways and 72.9% (6689) with no defined pathway. Patients in COVID-19 free surgical pathways were younger, less comorbid, and had better performance scores. Major surgery accounted for 75.6% (1866/2481) of operations in COVID-19 free surgical pathways and 77.7% (5179/6689) where there was no defined pathway; a full list of operations performed is provided in *Supplementary Table 2.* The missing data rates were low (*Appendix E*). Changes in local SARS-CoV-2 incidence over the study period are displayed in *Supplementary Table 1*.

Preoperative testing

Overall, 27.0% of patients (2473/9409) underwent preoperative SARS-CoV-2 testing; 75.9% (1878/2473) of this was performed using a swab test. The preoperative testing rate was higher in COVID-19 free surgical pathways versus patients with no defined pathway (39.1% [970] versus 22.5% [1503], p<0.0001).

Postoperative pulmonary complications

The overall 30-day pulmonary complication rate was 4.2% (385/9171), which was lower for patients within a COVID-19 free surgical pathway than with no defined pathway (2.2% [55/2481] versus 4.9% [329/6689], unadjusted odds ratio (OR) 0.49, 95% credible interval (C.I.) 0.36 to 0.66). After adjustment, surgery in a COVID-19 free surgical pathway remained associated with a lower

postoperative pulmonary complication rate (adjusted odds ratio (aOR) 0.62, 95% C.I. 0.44 to 0.86). Older age, male sex, ASA grades 3 to 5, poorer performance status, higher cardiac risk, pre-existing respiratory disease, advanced disease stage, major surgery, oesophagogastric surgery, and surgery in high SARS-CoV-2 incidence areas were also associated with greater odds of pulmonary complications (*Figure 2* and *Supplementary Table 3*).

Sensitivity analyses

Postoperative pulmonary complication rates stratified by age, sex, and ASA grade in hospitals with and without COVID-19 free surgical pathways are displayed in *Figure 3*. In a sensitivity analysis including only low risk patients (N=6489), COVID-19 free surgical pathways remained associated with reduced odds of pulmonary complications (aOR 0.58, 95% C.I. 0.36 to 0.93, *Supplementary Table 4*).

Propensity-score matching created well balanced groups (*Supplementary Table 5*) with 2449 patients within COVID-19 free surgical pathways matched to 2449 with no defined pathway. After adjustment, surgery within a COVID-19 free surgical pathway was associated with lower odds of pulmonary complications (aOR 0.65, 95% C.I. 0.44 to 0.96, *Supplementary Table* 6).

In a sensitivity analysis including only patients with a negative preoperative SARS-CoV-2 test (N=2447), again a COVID-19 free surgical pathway was associated with lower pulmonary complication rates (aOR 0.52, 95% C.I. 0.29 to 0.91, *Figure 4 and Supplementary Table 7*).

Surgical pathway components

Consecutive data were available for 4505 patients. Of these, 45.6% (2053/4505) were classified as having a COVID-19 free surgical pathway. Of 2451 patients with no defined pathway, 86.5% (2120/2451) had an operating room that was shared with COVID-19 patients, 21.5% (526/2451) a shared critical care, and 59.8% (1466/2451) a shared ward area. Treatment in both a COVID-19 free ward and critical care (aOR: 0.43, 95% C.I. 0.24 to 0.77), or a complete COVID-19 free surgical pathway (aOR: 0.30, 95% C.I. 0.17 to 0.54) was significantly associated with a lower odds of

pulmonary complications, versus patients treated in shared operating room, critical care, and ward areas (*Figure 5*).

Postoperative SARS-CoV-2 infection

The overall rate of postoperative SARS-CoV-2 infection was 3.2% (291/9171). A majority were confirmed with a swab test (85.6%, 249/291). The SARS-CoV-2 infection rate was lower in COVID-19 free surgical pathways (2.1%, 53/2481) than with no defined pathway (3.6%, 238/6820; aOR: 0.53, 95% C.I. 0.36 to 0.76). This was consistent in a sensitivity analysis with swab testing only (aOR: 0.44, 95% C.I. 0.28 to 0.68, *Supplementary Table 9*), and was consistent across hospitals in high (3.9% versus 8.2%) and low SARS-CoV-2 incidence areas (1.6% versus 3.1%) respectively (*Table 3*). SARS-CoV-2 infection was associated with increased pulmonary complication rates compared to non-infected patients (33.8% [130/385] versus 1.8% [161/8786]; OR: 29.78, 95% C.I. 22.4 to 39.6).

Postoperative mortality

The overall postoperative mortality rate was 1.5% (134/9115). Mortality was higher in patients with pulmonary complications (OR: 25.64, 95% C.I. 17.63 to 36.67) and in patients with a SARS-CoV-2 infection (OR: 29.34, 95% C.I. 20.13 to 43.04). It was lower in patients operated in COVID-19 free surgical pathways (OR: 0.45, 95% C.I. 0.25 to 0.78). Of the 30-day deaths, 49.3% (66/134) were associated with pulmonary complications and 44.0% (59/134) were associated with SARS-CoV-2 infections (*Figure 6*). Mortality was higher following pulmonary complications in SARS-CoV-2 patients (30.8%, 40/130) than in non-infected patients with pulmonary complications (10.7%, 26/244).

Discussion

This study identified that postoperative pulmonary complication rates were lower for patients in COVID-19 free surgical pathways during the SARS-CoV-2 pandemic. Despite a tendency for lower risk cases to be performed in these pathways, effects persisted after risk adjustment, sensitivity analyses and propensity score matching. The advantage of COVID-19 free pathways was also seen in patients with a negative SARS-CoV-2 test preoperatively. Older patients, males, and patients with cardiorespiratory comorbidities were consistently at greater risk of adverse outcomes. Mortality was primarily driven by pulmonary complications, which was low in COVID-19 free surgical pathways and high with postoperative SARS-CoV-2 infection. Overall, these data support major international redesign of surgical services to provide elective cancer surgery in COVID-19 free surgical pathways. Whilst the greatest effect size was seen in areas of high SARS-CoV-2 incidence, there was also a significant difference in outcomes in low incidence areas. Setup of COVID-19 free pathways is therefore likely to be justified both during the end phases of current lockdowns in preparation for second waves.

It is likely that differences in SARS-CoV-2 transmission rates are responsible for differences in pulmonary complications between COVID-19 free surgical pathways and hospitals with no defined pathway. Firstly, the rate of postoperative SARS-CoV-2 infection was consistently lower in COVID-19 free surgical pathways. Secondly, SARS-CoV-2 infection was associated with a very high rate of pulmonary complications. Thirdly, the benefit of COVID-19 free pathways was greatest where in high SARS-CoV-2 incidence areas. Finally, the effect size increased in proportion with the number of COVID-19 free components of the surgical pathway. The overall preoperative testing rate was low (27.0%) and testing was not associated with lower pulmonary complication rates in the main model. Furthermore, in a sensitivity analysis for patients with a negative preoperative swab test, the benefit of COVID-19 free pathways persisted.

Although we defined COVID-19 free pathways in the protocol, the exact nature varied across this pragmatic study. Comorbid and elderly patients will still need to undergo surgery in major acute hospitals due to resource availability (e.g. critical care, interventional radiology and/or multi-specialty

operations), and these hospitals are likely to continue to admit COVID-19 patients. COVID-19 free pathways must be robustly quality assured within these settings. Detailed evaluations of additional in-hospital measures to reduce SARS-CoV-2 exposure, including serial preoperative testing, Personal Protective Equipment, drug prophylaxis, staff testing, and perioperative isolation are still required.

The overall mortality rate with pulmonary complications (17.2%) is higher than would be expected when compared pre-pandemic rates [23–28]. Data from elective and emergency surgical patients has shown a high mortality associated with perioperative SARS-CoV-2 infection which is consistent with our series [5]. This information should be used routinely as part of informed consent for elective surgery.

There were limitations to this study. Firstly, the risk of selection bias in COVID-19 free surgical pathways was accounted for this through risk adjustment and planned sensitivity analyses. Despite this, COVID-19 free pathways may have been better resourced and there may have been residual bias. However, establishing COVID-19 free areas did not appear to be determined by resource availability alone; patients were operated in these pathways in 27 of 37 countries in which five or more centres participated. Secondly, we included swab, CT, and clinical diagnoses of COVID-19 in the definition of postoperative SARS-CoV-2 infection, to reflect variable access to testing during early phases of the pandemic [31]. However, only 14.4% of infected patients had a CT or clinical diagnosis, minimising the risk of incorrect diagnosis. Thirdly, borderline operable cancers and high-risk patients may not have been offered surgery during the pandemic, so the potential benefits of COVID-19 free surgical pathways may be even greater for this group [32, 33]. Fourthly, there is a possibility of incomplete case ascertainment, although we implemented a number of strategies to minimise this.

COVID-19 free surgical pathways, and entirely separate elective surgery hospital, may lead to unintended consequences that include reduction in capacity for other health conditions. These consequences will need to be monitored at a whole system level.

References

1. COVIDSurg Collaborative. *Elective surgery cancellations due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans.* Br J Surg, In print, May 2020.
2. Dai, M., et al., *Patients with cancer appear more vulnerable to SARS-COV-2: a multi-center study during the COVID-19 outbreak.* Cancer Discovery, 2020: p. CD-20-0422.
3. Liang, W., et al., *Cancer patients in SARS-CoV-2 infection: a nationwide analysis in China.* Lancet Oncol, 2020. **21**(3): p. 335-337.
4. Mehta, V., et al., *Case Fatality Rate of Cancer Patients with COVID-19 in a New York Hospital System.* Cancer Discov, 2020.
5. COVIDSurg Collaborative. *Mortality and pulmonary complications in patients undergoing surgery with perioperative SARS-CoV-2 infection: an international cohort study*, in print, *Lancet*. 2020.
6. Royal College of Surgeons of England. *Guidance for surgeons working during the COVID-19 pandemic from the Surgical Royal Colleges of the United Kingdom and Ireland.* 2020.
7. COVIDSurg Collaborative, *Global guidance for surgical care during the COVID-19 pandemic*, in *Br J Surg*. In print, May 2020.
8. Saini, K.S., et al., *Effect of the COVID-19 pandemic on cancer treatment and research.* Lancet Haematol, 2020. **7**(6): p. e432-e435.
9. NHS England. *NHS England and NHS Improvement Advice on maintaining cancer treatment during the COVID-19 response.* 2020 March 30th [cited 2020 June 6th Available from: https://www.england.nhs.uk/coronavirus/publication/advice-to-trusts-on-maintaining-cancer-treatment-during-the-covid-19-response/.
10. Sud, A., et al., *Quantifying and mitigating the impact of the COVID-19 pandemic on outcomes in colorectal cancer.* medRxiv, 2020.
11. British Association for Cancer Surgery. *BASO Guidance - Strategy for Cancer Surgery sustainability and recovery in the COVID 19 pandemic*. 2020.
12. Sullivan, R., et al., *Global cancer surgery: delivering safe, affordable, and timely cancer surgery.* Lancet Oncol, 2015. **16**(11): p. 1193-224.
13. Woo, Y.L., et al., *Centralisation of services for gynaecological cancers - a Cochrane systematic review.* Gynecol Oncol, 2012. **126**(2): p. 286-90.
14. Faluyi, O.O., et al., *Advanced pancreatic adenocarcinoma outcomes with transition from devolved to centralised care in a regional Cancer Centre.* Br J Cancer, 2017. **116**(4): p. 424-431.
15. Harris, P.A., et al., *Research electronic data capture (REDCap)--a metadata-driven methodology and workflow process for providing translational research informatics support.* J Biomed Inform, 2009. **42**(2): p. 377-81.
16. National Confidential Enquiry into Patient Outcome and Death. *The NCEPOD Classification of Intervention*. 2004 [cited 2020 June 6th; Available from: https://www.ncepod.org.uk/classification.html.
17. Bupa *Schedule of procedures*. 2020 [cited 2020 June 6th; Available from: https://codes.bupa.co.uk/home.
18. The Clinical Coding & Schedule Development Group. *Procedure Codes Schedule*. 2020 [cited 2020 June 6th; Available from: https://www.ccsd.org.uk/ccsdschedule.

19. Pearse, R.M., et al., *The Prevention of Respiratory Insufficiency after Surgical Management (PRISM) Trial. Report of the protocol for a pragmatic randomized controlled trial of CPAP to prevent respiratory complications and improve survival following major abdominal surgery.* Minerva Anestesiol, 2017. **83**(2): p. 175-182.
20. COVIDSurg Collaborative. *Mortality and pulmonary complications in patients undergoing surgery with perioperative SARS-CoV-2 infection: an international cohort study.* The Lancet (in press), 2020.
21. World Health Organisation. *WHO Coronavirus Disease (COVID-19) Dashboard* 2020 [cited 2020 June 6th; Available from: https://covid19.who.int/.
22. European Centre for Disease Prevention and Control. *Download today's data on the geographic distribution of COVID-19 cases worldwide*. 2020 [cited 2020 June 6th; Available from: https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases.
23. Centers for Disease Control and Prevention. *CDC COVID Data Tracker*. 2020 [cited 2020 June 6th; Available from: https://www.cdc.gov/covid-data-tracker/index.html.
24. European Centre for Disease Prevention and Control. *Coronavirus disease 2019 (COVID-19) pandemic: increased transmission in the EU/EEA and the UK – seventh update*. 2020 [cited 2020 June 6th; Rapid Risk Assessment. Stockholm]. Available from: https://www.ecdc.europa.eu/sites/default/files/documents/RRA-seventh-update-Outbreak-of-coronavirus-disease-COVID-19.pdf.
25. GlobalSurg, C., *Surgical site infection after gastrointestinal surgery in high-income, middle-income, and low-income countries: a prospective, international, multicentre cohort study.* Lancet Infect Dis, 2018. **18**(5): p. 516-525.
26. Gharaibeh, A., S. Koppikar, and F. J. Bonilla-Escobar, *Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) in the International Journal of Medical Students.* International Journal of Medical Students, 2014. **2**(2): p. 36-37.
27. Lang, T.A. and D.G. Altman, *Basic statistical reporting for articles published in biomedical journals: the "Statistical Analyses and Methods in the Published Literature" or the SAMPL Guidelines.* Int J Nurs Stud, 2015. **52**(1): p. 5-9.
28. Wickham, H., *The split-apply-combine strategy for data analysis.* Journal of Statistical Software, 2011. **40**(1): p. 1-29.
29. Kavanagh, M.M., et al., *Access to lifesaving medical resources for African countries: COVID-19 testing and response, ethics, and politics.* Lancet, 2020. **395**(10238): p. 1735-1738.
30. Biccard, B.M., et al., *Perioperative patient outcomes in the African Surgical Outcomes Study: a 7-day prospective observational cohort study.* Lancet, 2018. **391**(10130): p. 1589-1598.
31. Fernandez-Bustamante, A., et al., *Postoperative Pulmonary Complications, Early Mortality, and Hospital Stay Following Noncardiothoracic Surgery: A Multicenter Study by the Perioperative Research Network Investigators.* JAMA Surg, 2017. **152**(2): p. 157-166.

Table 1. Patients treated within COVID-19 free surgical pathways and with no defined pathway.

Factor	Levels	COVID-19 free surgical pathway N=2481	No defined pathway N=6689	P-value
Age, n (%)	<50 years	558 (22.5)	1086 (16.2)	<0.001
	50-59 years	576 (23.2)	1404 (21.0)	
	60-69 years	633 (25.5)	1911 (28.6)	
	70-79 years	552 (22.2)	1689 (25.3)	
	≥80 years	162 (6.5)	599 (9.0)	
Sex, n (%)	Female	1743 (70.3)	3832 (57.3)	<0.001
	Male	737 (29.7)	2856 (42.7)	
	(Missing)	1	1	
BMI, n (%)	Normal	996 (40.1)	2542 (38.0)	0.050
	Overweight	796 (32.1)	2091 (31.3)	
	Obese	469 (18.9)	1443 (21.6)	
	Underweight	53 (2.1)	164 (2.5)	
	Missing	167 (6.7)	449 (6.7)	
ASA Grade, n (%)	ASA grade 1-2	1959 (79.2)	4640 (69.7)	<0.001
	ASA grade 3-5	515 (20.8)	2016 (30.3)	
	(Missing)	7	33	
RCRI, n (%)	0	949 (38.3)	1942 (29.0)	<0.001
	1	1181 (47.6)	3453 (51.6)	
	2	306 (12.3)	1023 (15.3)	
	≥3	45 (1.8)	271 (4.1)	
Respiratory comorbidity, n (%)	No	2249 (90.6)	5929 (88.6)	0.007
	Yes	232 (9.4)	760 (11.4)	
ECOG Performance Score, n (%)	0	1657 (67.1)	4087 (62.2)	<0.001
	1-2	775 (31.4)	2367 (36.0)	
	3-4	36 (1.5)	115 (1.8)	
	(Missing)	13	120	
Cancer type, n (%)	Colorectal	437 (17.6)	1873 (28.0)	<0.001
	Breast	827 (33.3)	1313 (19.6)	
	Gynaecological	330 (13.3)	772 (11.5)	
	Head or neck	253 (10.2)	884 (13.2)	
	Hepatopancreatobilary	161 (6.5)	515 (7.7)	
	Intracranial	34 (1.4)	130 (1.9)	
	Thoracic	172 (6.9)	385 (5.8)	
	Oesophagogastric	75 (3.0)	312 (4.7)	
	Sarcoma	118 (4.8)	143 (2.1)	
	Urological	74 (3.0)	362 (5.4)	
Disease stage, n (%)	Early stage	1822 (73.5)	4707 (70.4)	0.004
	Advanced stage	657 (26.5)	1978 (29.6)	
	(Missing)	2	4	
Booking type, n (%)	Daycase	206 (8.4)	524 (7.9)	0.493
	Inpatient	2259 (91.6)	6117 (92.1)	
	(Missing)	16	48	
Anaesthetic, n (%)	Regional/local anaesthetic	99 (4.0)	388 (5.8)	0.001
	General anaesthetic	2382 (96.0)	6301 (94.2)	
Operation grade, n (%)	Minor	601 (24.4)	1488 (22.3)	0.042
	Major	1866 (75.6)	5179 (77.7)	
	(Missing)	14	22	
Preoperative testing, n (%)	Not screened	1511 (60.9)	5186 (77.5)	<0.001
	Screened	970 (39.1)	1503 (22.5)	
Community SARS-Cov-2 risk, n (%)	Low	1948 (78.5)	6079 (90.9)	<0.001
	High	533 (21.5)	610 (9.1)	

COVID-19=Coronavirus disease 2019. ASA=American Society of Anaesthesiologists. RCRI=Revised Cardiac Risk Index. ECOG=Eastern Cooperative Oncology Group. Please see *Appendix C* for full definitions. Percentages calculated as a proportion of column total. P-values calculated using X^2 test.

Table 2. Comparison of patients with and without postoperative pulmonary complications.

Factor	Levels	No pulmonary Complications N=8786	Pulmonary Complications N=385	P-value
Age, n (%)	<50 years	1624 (18.5)	20 (5.2)	<0.001
	50-59 years	1929 (22.0)	51 (13.2)	
	60-69 years	2427 (27.6)	118 (30.6)	
	70-79 years	2096 (23.9)	145 (37.7)	
	≥80 years	710 (8.1)	51 (13.2)	
Sex, n (%)	Female	5455 (62.1)	121 (31.4)	<0.001
	Male	3329 (37.9)	264 (68.6)	
	(Missing)	2	0	
BMI, n (%)	Normal	3403 (38.7)	135 (35.1)	0.100
	Overweight	2771 (31.5)	117 (30.4)	
	Obese	1827 (20.8)	85 (22.1)	
	Underweight	207 (2.4)	10 (2.6)	
	Missing	578 (6.6)	38 (9.9)	
ASA Grade, n (%)	ASA grade 1-2	6408 (73.3)	192 (50.1)	<0.001
	ASA grade 3-5	2340 (26.7)	191 (49.9)	
	(Missing)	38	2	
Current smoker, n (%)	No	7843 (89.3)	321 (83.4)	<0.001
	Yes	943 (10.7)	64 (16.6)	
Pre-existing respiratory condition, n (%)	No	7873 (89.6)	306 (79.5)	<0.001
	Yes	913 (10.4)	79 (20.5)	
RCRI, n (%)	0	2859 (32.5)	33 (8.6)	<0.001
	1	4413 (50.2)	221 (57.4)	
	2	1240 (14.1)	89 (23.1)	
	≥3	274 (3.1)	42 (10.9)	
ECOG Performance Score, n (%)	0	5597 (64.7)	148 (38.6)	<0.001
	1-2	2922 (33.8)	220 (57.4)	
	3-4	136 (1.6)	15 (3.9)	
	(Missing)	131	2	
Cancer type, n (%)	Colorectal	2176 (24.8)	134 (34.8)	<0.001
	Breast	2132 (24.3)	9 (2.3)	
	Gynaecological	1082 (12.3)	20 (5.2)	
	Head or neck	1096 (12.5)	41 (10.6)	
	Hepatopancreatobilary	626 (7.1)	50 (13.0)	
	Intracranial	162 (1.8)	2 (0.5)	
	Thoracic	516 (5.9)	41 (10.6)	
	Oesophagogastric	322 (3.7)	65 (16.9)	
	Sarcoma	253 (2.9)	8 (2.1)	
	Urological	421 (4.8)	15 (3.9)	
Disease stage, n (%)	Early stage	6308 (71.8)	222 (57.7)	<0.001
	Advanced stage	2472 (28.2)	163 (42.3)	
	(Missing)	6	0	
Booking type, n (%)	Daycase	729 (8.4)	1 (0.3)	<0.001
	Inpatient	7994 (91.6)	383 (99.7)	
	(Missing)	63	1	
Anaesthetic, n (%)	Regional/local anaesthetic	458 (5.2)	29 (7.5)	0.061
	General anaesthetic	8328 (94.8)	356 (92.5)	
Operation grade, n (%)	Minor	2062 (23.6)	27 (7.0)	<0.001
	Major	6689 (76.4)	356 (93.0)	
	(Missing)	35	2	
Preoperative testing, n (%)	Not tested	6412 (73.0)	286 (74.3)	0.612
	Tested	2374 (27.0)	99 (25.7)	
Hospital type, n (%)	COVID-19 free surgical pathway	2426 (27.6)	55 (14.3)	<0.001
	No defined pathway	6360 (72.4)	329 (85.7)	
	(Missing)	0	1	
Community SARS-Cov-2 risk, n (%)	Low	7694 (87.6)	334 (86.8)	0.692
	High	1092 (12.4)	51 (13.2)	

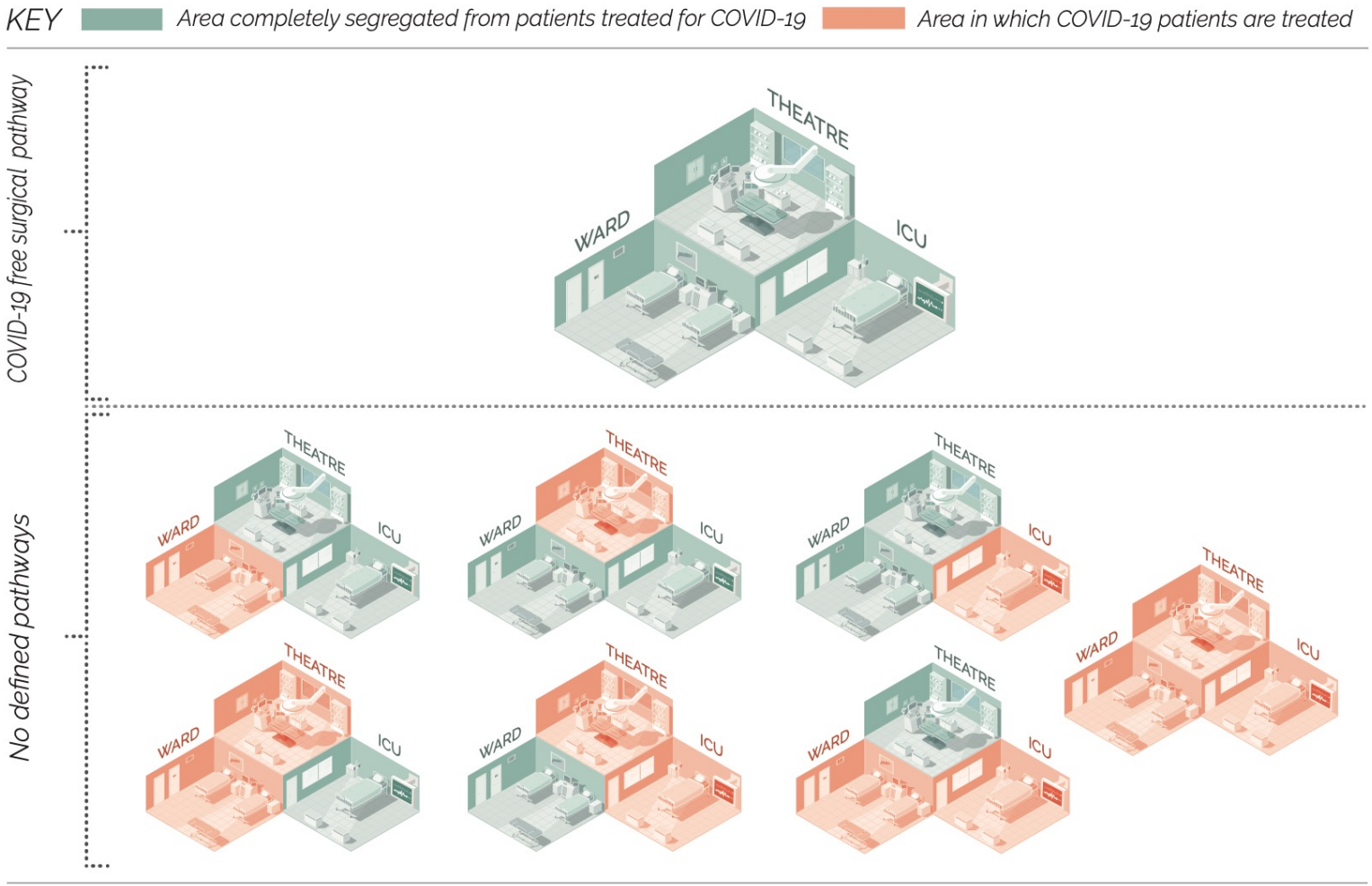
COVID-19=Coronavirus disease 2019. ASA=American Society of Anaesthesiologists. RCRI=Revised Cardiac Risk Index. ECOG=Eastern Cooperative Oncology Group. Please see *Appendix C* for full definitions. Percentages calculated as a proportion of row total. P-values calculated using X^2 test.

Table 3. Clinical outcomes for patients undergoing surgery in a COVID-19 free surgical pathway versus hospitals with no defined pathway, split by low versus high community SARS-CoV-2 incidence.

		COVID-19 free surgical pathway N=2481	No defined pathway N=6689
Low community SARS-CoV-2 incidence area	Pulmonary complications	**2.2%** (1.6% - 3.0%) 43/1948	**4.8%** (4.2%-5.3%) 290/6079
	SARS-CoV-2 infection	**1.6%** (1.1%-2.3%) 32/1948	**3.1%** (2.7%-3.6%) 188/6079
	30-day mortality	**0.7%** (0.4-1.2%) 14/1939	**1.7%** (1.4%-2.1%) 103/6041
	30-day mortality and SARS-CoV-2 infection	**0.01%** (0.001%-0.04%) 2/1939	**0.7%** (0.5%-1.0%) 44/6041
High community SARS-CoV-2 incidence area	Pulmonary complications	**2.3%** (1.2-3.9%) 12/533	**6.4%** (4.6%-8.6%) 39/610
	SARS-CoV-2 infection	**3.9%** (2.5%-6.0%) 21/533	**8.2%** (6.1%-10.7%) 50/610
	30-day mortality	**0.9%** (0.3%-2.2%) 5/527	**2.1%** (1.1%-3.6%) 13/608
	30-day mortality and SARS-CoV-2 infection	**0.8%** (0.2%-1.9%) 4/527	**1.4%** (0.7%-2.8%) 9/608

Pulmonary complications were defined as pneumonia, acute respiratory distress syndrome (ARDS), and/or unexpected postoperative ventilation. SARS-CoV-2=Severe acute respiratory syndrome coronavirus 2. Areas defined as 'high' (30-day cumulative notification rate of ≥25 cases per 100,000 population) or 'low' (14-day cumulative notification rate of <25 cases per 100,000 population) according to European Centre for Disease Control and Prevention reporting criteria during two-week periods in March and April 2020. Proportions are presented as mean averages with 95% confidence intervals calculated using the Pearson-Klopper exact method (package: binom.confint).

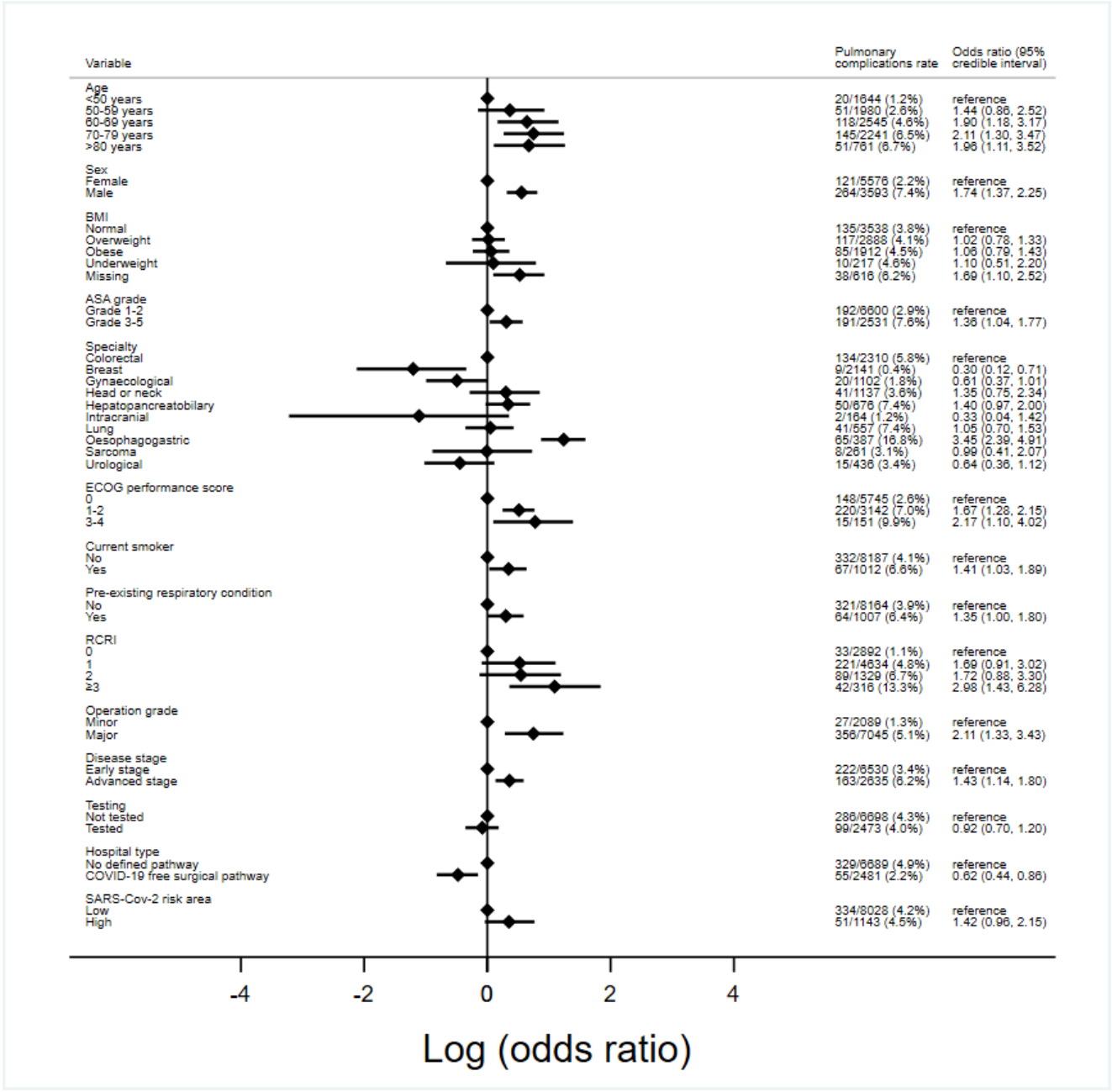
Figure 1. Differences between hospitals with a COVID-19 free surgical pathway and hospitals with no defined pathway



COVID-19 free surgical pathways: complete segregation of operating room, critical care and inpatient ward areas for elective cancer surgery, away from patients being treated for COVID-19.

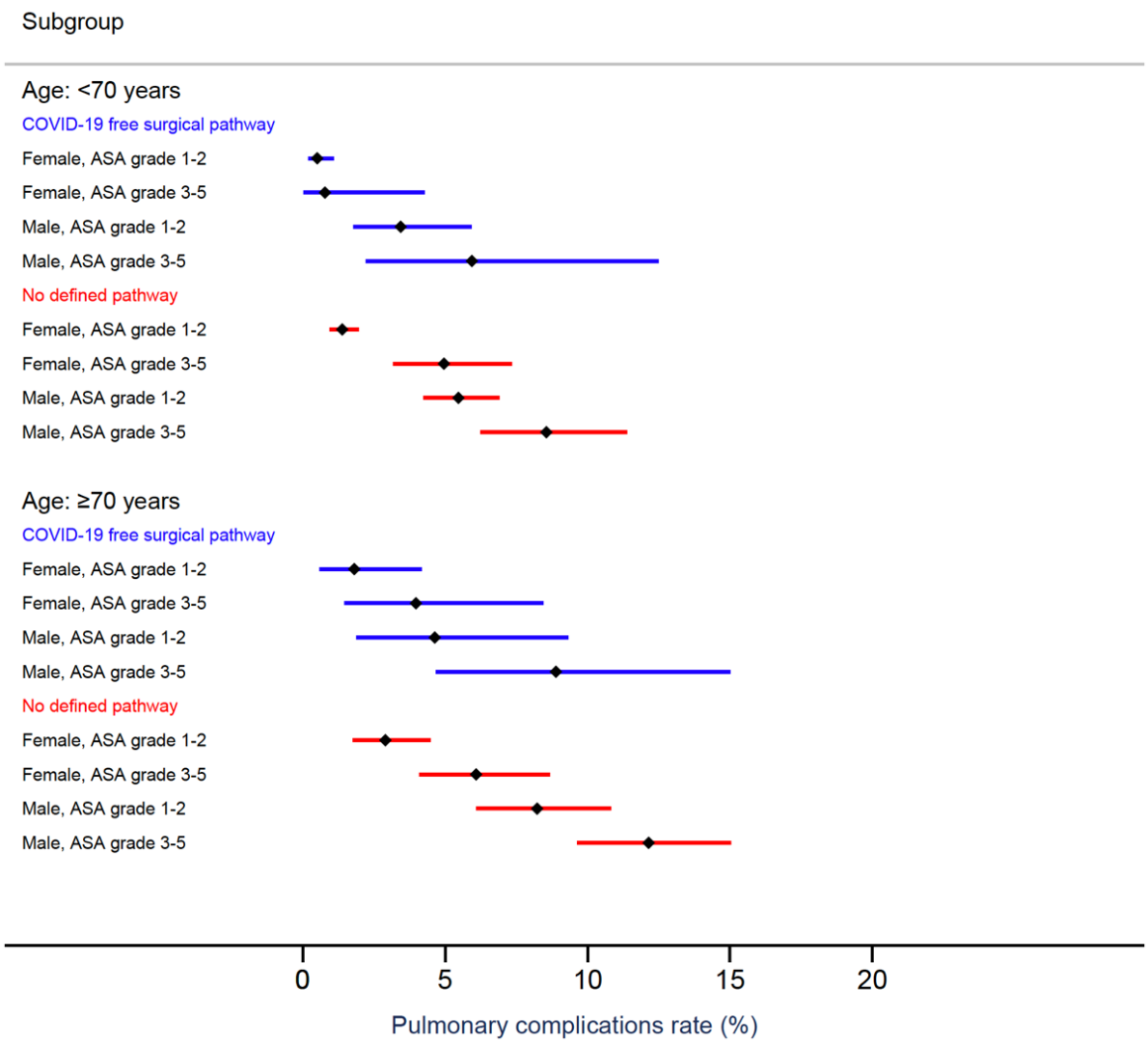
No defined pathways: hospitals where there was mixing of patients undergoing treatment for COVID-19 and elective surgical patients in any operating theatre, critical care or inpatient ward areas.

Figure 2. Factors associated with postoperative pulmonary complications after elective cancer surgery



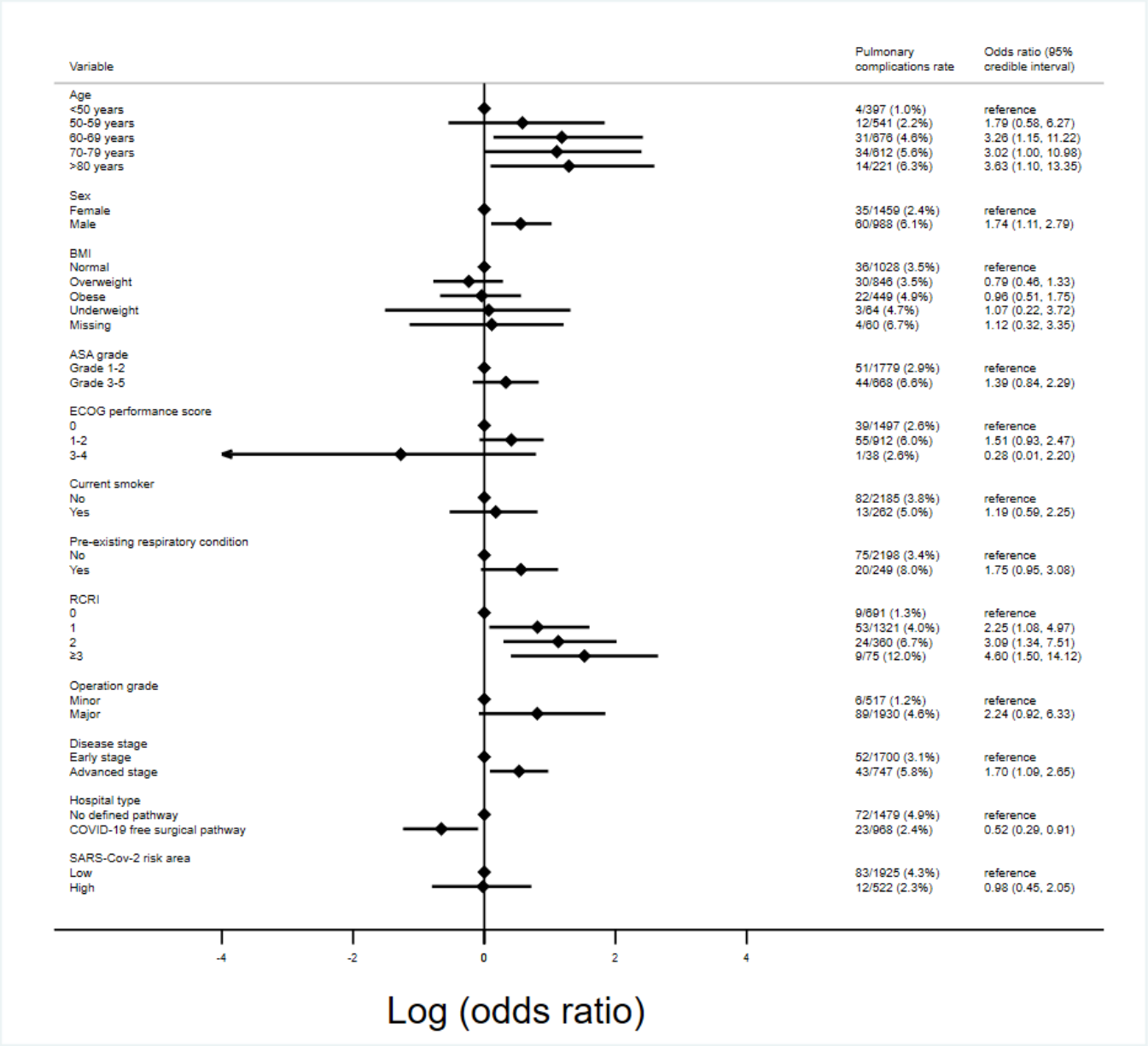
Included data from 8971 patients with complete data. See *Supplementary Table 3* for full model. COVID-19=Coronavirus disease 2019. ASA=American Society of Anaesthesiologists. RCRI=Revised Cardiac Risk Index. ECOG=Eastern Cooperative Oncology Group. Please see *Appendix C* for full definitions.

Figure 3. Proportion of patient with postoperative pulmonary complications across key risk groups within COVID-19 free surgical pathways versus hospitals with no defined pathway.



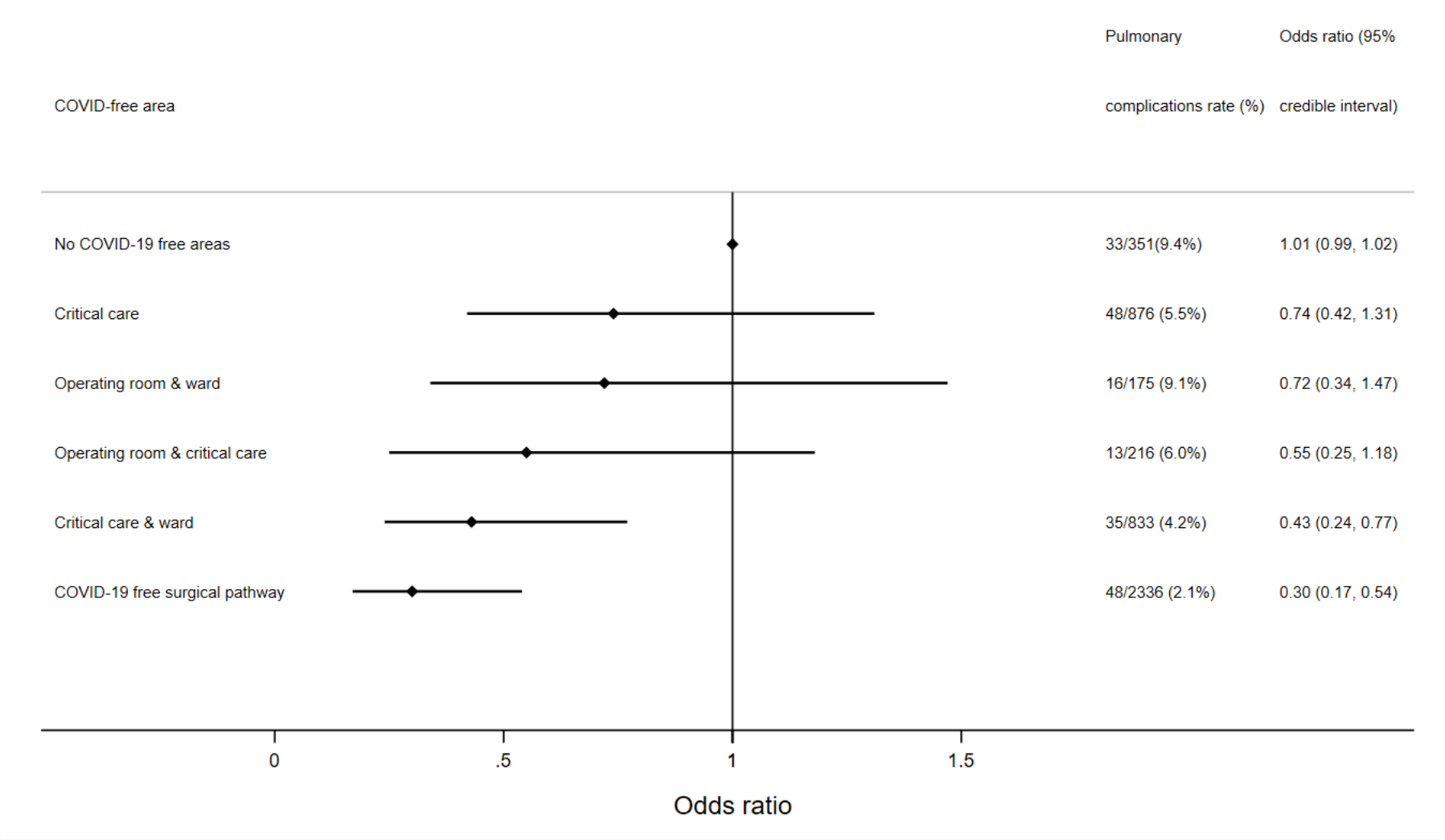
ASA=American Society of Anaesthesiologists. Proportions are given as percentage of total patients operated in COVID-19 free surgical pathways (n=2552, blue) or hospitals with no defined pathway (n=6886, red). Male gender and ASA grade 3-5 were seen consistently to increase the rate of pulmonary complications for patients in COVID-19 free surgical pathways and where no pathway was defined.

Figure 4. Factors associated with postoperative pulmonary complications after elective cancer surgery in patients with a negative preoperative SARS-CoV-2 swab test.



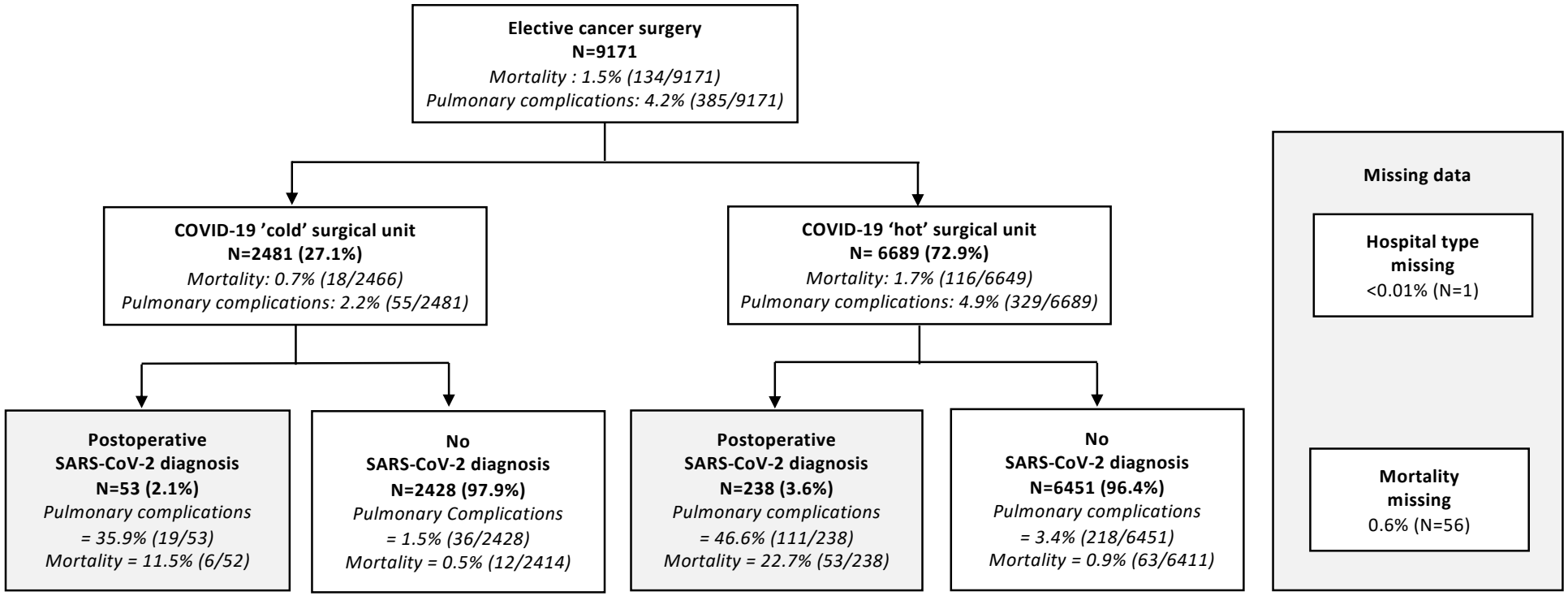
Included data from 2447 patients with complete data. See *Supplementary Table 7* for full model. COVID-19=Coronavirus disease 2019. ASA=American Society of Anaesthesiologists. RCRI=Revised Cardiac Risk Index. ECOG=Eastern Cooperative Oncology Group. Please see *Appendix C* for full definitions.

Figure 5. Association of components of a COVID-19 free surgical pathway with postoperative pulmonary complications.



Included data from 4787 patients with complete data. For each patient, the operating room, critical care (where applicable) and ward areas were defined as COVID-19 free or shared with patients treated for COVID-19. COVID-19=Coronavirus disease 2019. ASA=American Society of Anaesthesiologists. RCRI=Revised Cardiac Risk Index. ECOG=Eastern Cooperative Oncology Group. Please see *Appendix C* for full definitions.

Figure 6. Rates of pulmonary complications, SARS-CoV-2, and death in COVID-19 free surgical pathways versus hospitals with no defined pathway.



Pulmonary complications were defined as pneumonia, acute respiratory distress syndrome (ARDS), and/or unexpected postoperative ventilation. SARS-CoV-2=Severe acute respiratory syndrome coronavirus 2.

Supplementary Table 1. Community risk of SARS-CoV-2 transmission in areas of participating hospitals

Hospital details			Patient operation location		Population data			Data available	Community SARS-CoV-2 *March (Week 1-2)*			Community SARS-CoV-2 *March (Week 3-4)*			Community SARS-CoV-2 *April (Week 1-2)*			Community SARS-CoV-2 *April (Week 1-2)*		
Hospital name	Country	City	COVID-19 free surgical pathway	No defined pathway	City	Region	Country		Cases	incidence	Risk	Cases	incidence	Risk	Cases	incidence	Risk	Cases	incidence	Risk
Sanatorio Allende	Argentina	Cordoba	4 (13.8)	25 (86.2)		3308876		Region	3	0.1	Low	93	2.8	Low	136	4.1	Low	50	1.5	Low
Hospital Italiano de Buenos Aires	Argentina	Buenos Aires		8 (100.0)	2891082			City	32	1.1	Low	355	12.3	Low	454	15.7	Low	724	25.0	High
Sanatorio 9 de julio SA	Argentina	Tucuman		6 (100.0)		1448188		Region	0	0.0	Low	16	1.1	Low	14	1.0	Low	8	0.6	Low
Nairi Medical Center	Armenia	Yerevan	3 (100.0)				2951745	Country	28	0.9	Low	543	18.4	Low	588	19.9	Low	989	33.5	High
Flinders Medical Centre	Australia	Adelaide	4 (17.4)	19 (82.6)		1756494		Region	17	1.0	Low	285	16.2	Low	128	7.3	Low	5	0.3	Low
Royal Adelaide Hospital	Australia	Adelaide	1 (3.2)	30 (96.8)		1756494		Region	17	1.0	Low	285	16.2	Low	128	7.3	Low	5	0.3	Low
Royal Brisbane and Women's Hospital	Australia	Brisbane	1 (1.8)	54 (98.2)		5115451		Region	53	1.0	Low	681	13.3	Low	256	5.0	Low	34	0.7	Low
Canberra Hospital	Australia	Canberra	1 (100.0)			428060		Region	1	0.2	Low	79	18.5	Low	23	5.4	Low	3	0.7	Low
Coffs Harbour Health Campus	Australia	Coffs Harbour NSW	2 (50.0)	2 (50.0)		8117976		Region	128	1.6	Low	1899	23.4	Low	854	10.5	Low	130	1.6	Low
St Vincent's Hospital	Australia	Melbourne	12 (42.9)	16 (57.1)		6629870		Region	53	0.8	Low	860	13.0	Low	382	5.8	Low	62	0.9	Low
Fiona Stanley Hospital	Australia	Perth	3 (12.5)	21 (87.5)		2630557		Region	16	0.6	Low	346	13.2	Low	168	6.4	Low	19	0.7	Low
Lifehouse	Australia	Sydney	5 (100.0)			8117976		Region	128	1.6	Low	1899	23.4	Low	854	10.5	Low	130	1.6	Low
Princess Alexandra Hospital	Australia	Brisbane		7 (100.0)		5115451		Region	53	1.0	Low	681	13.3	Low	256	5.0	Low	34	0.7	Low
Logan Hospital	Australia	Brisbane		17 (100.0)		5115451		Region	53	1.0	Low	681	13.3	Low	256	5.0	Low	34	0.7	Low
QEII jubilee Hospital	Australia	Brisbane		8 (100.0)		5115451		Region	53	1.0	Low	681	13.3	Low	256	5.0	Low	34	0.7	Low
Cairns Hospital	Australia	Cairns		1 (100.0)		5115451		Region	53	1.0	Low	681	13.3	Low	256	5.0	Low	34	0.7	Low
Lismore Base Hospital	Australia	Lismore		9 (100.0)		8117976		Region	128	1.6	Low	1899	23.4	Low	854	10.5	Low	130	1.6	Low
Calvary Mater Newcastle	Australia	Newcastle		10 (100.0)		8117976		Region	128	1.6	Low	1899	23.4	Low	854	10.5	Low	130	1.6	Low
John Hunter Hospital	Australia	Newcastle		40 (100.0)		8117976		Region	128	1.6	Low	1899	23.4	Low	854	10.5	Low	130	1.6	Low
Gold Coast University Hospital	Australia	Southport		17 (100.0)		5115451		Region	53	1.0	Low	681	13.3	Low	256	5.0	Low	34	0.7	Low
Concord Repatriation General Hospital	Australia	Sydney		5 (100.0)		8117976		Region	128	1.6	Low	1899	23.4	Low	854	10.5	Low	130	1.6	Low
Kardinal Schwarzenberg Klinikum	Austria	Schwarzach im Pongau	2 (100.0)				8902600	Country	855	9.6	Low	9114	102.4	High	4347	48.8	High	1103	12.4	Low
Landeskrankenhaus Feldkirch	Austria	Feldkirch		1 (100.0)			8902600	Country	855	9.6	Low	9114	102.4	High	4347	48.8	High	1103	12.4	Low
Medical University of Innsbruck	Austria	Innsbruck		86 (100.0)			8902600	Country	855	9.6	Low	9114	102.4	High	4347	48.8	High	1103	12.4	Low
Paracelsus Medical University Salzburg	Austria	Salzburg		10 (100.0)			8902600	Country	855	9.6	Low	9114	102.4	High	4347	48.8	High	1103	12.4	Low
Leyla Medical Centerl	Azerbaijan	Baku	1 (100.0)				10027874	Country	22	0.2	Low	273	2.7	Low	955	9.5	Low	551	5.5	Low
Queen Elizabeth Hospital	Barbados	Bridgetown	4 (100.0)				277821	Country	0	0.0	Low	33	11.9	Low	39	14.0	Low	8	2.9	Low
AZ Delta	Belgium	Roeselare		1 (100.0)		6589069		Region	971	14.7	Low	8721	132.4	High	11889	180.4	High	6129	93.0	High
Hospital Geral de Pirajussara	Brazil	Taboão da Serra		3 (100.0)		41262199		Region	134	0.3	Low	2203	5.3	Low	8704	21.1	Low	17655	42.8	High

St. Mary's Hospital	Canada	Montreal	6 (100.0)			8164361		Region	35	0.4	Low	4126	50.5	High	10698	131.0	High	12678	155.3	High
London Health Sciences Centre and St Josephs Health Care London	Canada	London		1 (100.0)		13448494		Region	134	1.0	Low	1821	13.5	Low	6481	48.2	High	7740	57.6	High
Jewish General Hospital	Canada	Montreal		16 (100.0)		8164361		Region	35	0.4	Low	4126	50.5	High	10698	131.0	High	12678	155.3	High
McGill University Health Center	Canada	Montreal		3 (100.0)		8164361		Region	35	0.4	Low	4126	50.5	High	10698	131.0	High	12678	155.3	High
The Ottawa Hospital	Canada	Ottawa		9 (100.0)		13448494		Region	134	1.0	Low	1821	13.5	Low	6481	48.2	High	7740	57.6	High
Saint John Regional Hospital	Canada	Saint John		1 (100.0)		747101		Region	6	0.8	Low	64	8.6	Low	47	6.3	Low	1	0.1	Low
Clínica Universitaria de Concepción	Chile	Concepción	6 (100.0)			1557414		Region	3	0.2	Low	213	13.7	Low	326	20.9	Low	185	11.9	Low
Clínica san diego	Colombia	Bogotá	9 (100.0)				50372424	Country	45	0.1	Low	861	1.7	Low	2199	4.4	Low	3402	6.8	Low
Subred Sur Occidente de Kennedy (Hospital de Kennedy)	Colombia	Bogota		1 (100.0)			50372424	Country	45	0.1	Low	861	1.7	Low	2199	4.4	Low	3402	6.8	Low
University Hospital Center	Croatia	Rijeka		7 (100.0)			4076246	Country	42	1.0	Low	818	20.1	Low	874	21.4	Low	1209	29.7	High
Zadar General Hospital	Croatia	Zadar		4 (100.0)			4076246	Country	42	1.0	Low	818	20.1	Low	874	21.4	Low	1209	29.7	High
Nicosia General Hospital	Cyprus	Nicosia		13 (100.0)			1189265	Country	33	2.8	Low	229	19.3	Low	453	38.1	High	135	11.4	Low
Hospital & Oncological Centre Novy Jicin	Czech Republic	Novy Jicin		7 (100.0)			10649800	Country	298	2.8	Low	3010	28.3	High	2993	28.1	High	1381	13.0	Low
Slezská nemocnice v Opavě, p.o.	Czech Republic	Opava		1 (100.0)			10649800	Country	298	2.8	Low	3010	28.3	High	2993	28.1	High	1381	13.0	Low
University Hospital Ostrava	Czech Republic	Ostrava		17 (100.0)			10649800	Country	298	2.8	Low	3010	28.3	High	2993	28.1	High	1381	13.0	Low
Aarhus University Hospital	Denmark	Aarhus		3 (100.0)			5822763	Country	872	15.0	Low	2164	37.2	High	3837	65.9	High	2480	42.6	High
Bispebjerg Hospital	Denmark	Copenhagen		19 (100.0)			5822764	Country	872	15.0	Low	2164	37.2	High	3837	65.9	High	2480	42.6	High
Alexandria Main University Hospital	Egypt	Alexandria	18 (100.0)				100075480	Country	93	0.1	Low	616	0.6	Low	1795	1.8	Low	3032	3.0	Low
Alexandria Medical Research Institute	Egypt	Alexandria	7 (100.0)				100075480	Country	93	0.1	Low	616	0.6	Low	1795	1.8	Low	3032	3.0	Low
MISR Cancer Center	Egypt	Al Jizah	6 (42.9)	8 (57.1)			100075480	Country	93	0.1	Low	616	0.6	Low	1795	1.8	Low	3032	3.0	Low
Assiut University Hospital	Egypt	Assiut		3 (100.0)			100075480	Country	93	0.1	Low	616	0.6	Low	1795	1.8	Low	3032	3.0	Low
National Cancer Institute	Egypt	Cairo		24 (100.0)			100075480	Country	93	0.1	Low	616	0.6	Low	1795	1.8	Low	3032	3.0	Low
Al Azhar University Hospitals	Egypt	Cairo		3 (100.0)			100075480	Country	93	0.1	Low	616	0.6	Low	1795	1.8	Low	3032	3.0	Low
National Liver Institute, Menoufia University	Egypt	Shibin Elkom		12 (100.0)			100075480	Country	93	0.1	Low	616	0.6	Low	1795	1.8	Low	3032	3.0	Low
Maddawalabu University Goba Referral Hospital	Ethiopia	Goba		1 (100.0)			109224414	Country	4	0.0	Low	22	0.0	Low	59	0.1	Low	46	0.0	Low
Oulu University Hospital	FInland	Oului	1 (2.6)	37 (97.4)			5526774	Country	333	6.0	Low	1344	24.3	Low	1993	36.1	High	1583	28.6	High
Länsi-Pohja Central Hospital	Finland	Kemi		12 (100.0)			5526774	Country	333	6.0	Low	1344	24.3	Low	1993	36.1	High	1583	28.6	High
institut mutualiste montsouris	France	Paris	1 (2.8)	35 (97.2)			67076000	Country	5323	7.9	Low	46705	69.6	High	54078	80.6	High	23375	34.8	High
HUS, Pole Hépato-Digestif / IHU-Strasbourg	France	Strasbourg	3 (23.1)	10 (76.9)			67076000	Country	5323	7.9	Low	46705	69.6	High	54078	80.6	High	23375	34.8	High

CHU Amiens	France	Amiens		21 (100.0)			67076000	Country	5323	7.9	Low	46705	69.6	High	54078	80.6	High	23375	34.8	High
Centre Hospitalier Avignon	France	Avignon		7 (100.0)			67076000	Country	5323	7.9	Low	46705	69.6	High	54078	80.6	High	23375	34.8	High
CHU Besançon	France	Besancon		10 (100.0)			67076000	Country	5323	7.9	Low	46705	69.6	High	54078	80.6	High	23375	34.8	High
CHU Lille	France	Lille		28 (100.0)			67076000	Country	5323	7.9	Low	46705	69.6	High	54078	80.6	High	23375	34.8	High
CHU Limoges	France	Limoges		32 (100.0)			67076000	Country	5323	7.9	Low	46705	69.6	High	54078	80.6	High	23375	34.8	High
Chu de Nantes Neurochirurgie	France	Nantes		1 (100.0)			67076000	Country	5323	7.9	Low	46705	69.6	High	54078	80.6	High	23375	34.8	High
Hôpital Cochin - APHP	France	Paris		1 (100.0)			67076000	Country	5323	7.9	Low	46705	69.6	High	54078	80.6	High	23375	34.8	High
Hopital Lyon Sud	France	Pierre Bénite		11 (100.0)			67076000	Country	5323	7.9	Low	46705	69.6	High	54078	80.6	High	23375	34.8	High
CHU Rennes - General Surgery	France	Rennes		3 (100.0)			67076000	Country	5323	7.9	Low	46705	69.6	High	54078	80.6	High	23375	34.8	High
Hia Begin	France	St Mande		3 (100.0)			67076000	Country	5323	7.9	Low	46705	69.6	High	54078	80.6	High	23375	34.8	High
CHRU NANCY	France	Vandoeuvre-lès-Nancy		1 (100.0)			67076000	Country	5323	7.9	Low	46705	69.6	High	54078	80.6	High	23375	34.8	High
University Hospital Carl Gustav Carus Dresden	Germany	dresden	1 (1.5)	65 (98.5)		4077937		Region	130	3.2	Low	1752	43.0	High	1937	47.5	High	742	18.2	Low
Heilig Geist Hospital	Germany	Bensheim		5 (100.0)		6243262		Region	286	4.6	Low	2997	48.0	High	3064	49.1	High	1957	31.3	High
University Hospital Giessen and Marburg	Germany	Giessen		2 (100.0)		6243262		Region	286	4.6	Low	2997	48.0	High	3064	49.1	High	1957	31.3	High
University Hospital Goettingen / Universitätsmedizin Goettingen	Germany	Goettingen		11 (100.0)		7962775		Region	287	3.6	Low	3776	47.4	High	3956	49.7	High	2048	25.7	High
University Medical Center Hamburg-Eppendorf	Germany	Hamburg		31 (100.0)	1822445			City	162	8.9	Low	2029	111.3	High	1678	92.1	High	693	38.0	High
Nordstadt Hospital	Germany	Hannover		6 (100.0)		7962775		Region	287	3.6	Low	3776	47.4	High	3956	49.7	High	2048	25.7	High
Universitätsmedizin der Johannes Gutenberg-Universität	Germany	Mainz		1 (100.0)		4084800		Region	168	4.1	Low	2558	62.6	High	2278	55.8	High	1025	25.1	High
Klinikum Rechts der Isar TUM School of Medicine	Germany	Munich		10 (100.0)		13076721		Region	871	6.7	Low	13924	106.5	High	19484	149.0	High	7786	59.5	High
LMU Klinikum	Germany	Munich		31 (100.0)		13076721		Region	871	6.7	Low	13924	106.5	High	19484	149.0	High	7786	59.5	High
Ludwig Maximilian University of Munich	Germany	Munich		8 (100.0)		13076721		Region	871	6.7	Low	13924	106.5	High	19484	149.0	High	7786	59.5	High
RoMed Klinikum Rosenheim	Germany	Rosenheim		27 (100.0)		13076721		Region	871	6.7	Low	13924	106.5	High	19484	149.0	High	7786	59.5	High
University Hospital Halle (Saale)	Germany	Saale		25 (100.0)		2208321		Region	47	2.1	Low	633	28.7	High	543	24.6	Low	326	14.8	Low
University Hospital Tuebingen	Germany	Tuebingen		31 (100.0)		11023424		Region	813	7.4	Low	11507	104.4	High	12706	115.3	High	6569	59.6	High
Alexandra General Hospital	Greece	Athens	10 (100.0)				10724599	Country	324	3.0	Low	983	9.2	Low	878	8.2	Low	399	3.7	Low
Henry Dunant Hospital Center	Greece	Athens	5 (100.0)				10724599	Country	324	3.0	Low	983	9.2	Low	878	8.2	Low	399	3.7	Low
Naval And Veterans Hospital	Greece	Athens	1 (100.0)				10724599	Country	324	3.0	Low	983	9.2	Low	878	8.2	Low	399	3.7	Low
University Hospital of Heraklion Crete and Interclinic Hospital of Crete	Greece	Heraklion Crete	13 (92.9)	1 (7.1)			10724599	Country	324	3.0	Low	983	9.2	Low	878	8.2	Low	399	3.7	Low

Papageorgiou General Hospital	Greece	Thessaloniki	6 (100.0)				10724599	Country	324	3.0	Low	983	9.2	Low	878	8.2	Low	399	3.7	Low
Aretaieion Hospital	Greece	Athens		26 (100.0)			10724599	Country	324	3.0	Low	983	9.2	Low	878	8.2	Low	399	3.7	Low
Attikon University General Hospital	Greece	Athens		19 (100.0)			10724599	Country	324	3.0	Low	983	9.2	Low	878	8.2	Low	399	3.7	Low
Evaggelismos General Hospital	Greece	Athens		3 (100.0)			10724599	Country	324	3.0	Low	983	9.2	Low	878	8.2	Low	399	3.7	Low
Laiko University Hospital	Greece	Athens		15 (100.0)			10724599	Country	324	3.0	Low	983	9.2	Low	878	8.2	Low	399	3.7	Low
General University Hospital of Larissa	Greece	Larrisa		8 (100.0)			10724599	Country	324	3.0	Low	983	9.2	Low	878	8.2	Low	399	3.7	Low
George Papanikolaou General Hospital of Thessaloniki	Greece	Thessaloniki		20 (100.0)			10724599	Country	324	3.0	Low	983	9.2	Low	878	8.2	Low	399	3.7	Low
Queen Mary Hospital	Hong Kong SAR, China	Pok Fu Lam		12 (100.0)			7482500	Country	50	0.7	Low	566	7.6	Low	303	4.0	Low	21	0.3	Low
Prince of Wales Hospital	Hong Kong SAR, China	Sha Tin		69 (100.0)			7482500	Country	50	0.7	Low	566	7.6	Low	303	4.0	Low	21	0.3	Low
National Institute of Oncology	Hungary	Budapest	1 (100.0)		1752286			City	107.5	6.1	Low	107.5	6.1	Low	555	31.7	High	598	34.1	High
Szent Borbála Kórház	Hungary	Tatabánya	13 (44.8)	16 (55.2)		299110		Region	6	2.0	Low	6	2.0	Low	8	2.7	Low	81	27.1	High
Sher-i-Kashmir Institute of Medical Sciences	India	Srinagar		1 (100.0)		12258433		Region	2	0.0	Low	52	0.4	Low	224	1.8	Low	303	2.5	Low
SMHS HOSPITAL, Government Medical College	India	Srinagar		1 (100.0)		12258433		Region	2	0.0	Low	52	0.4	Low	224	1.8	Low	303	2.5	Low
South Infirmary Victoria University Hospital	Ireland	Cork	8 (100.0)			542868		Region	48	8.8	Low	224	41.3	High	673	124.0	High	211	38.9	High
Connolly Hospital Blanchardstown	Ireland	Dublin	1 (33.3)	2 (66.7)		1345402		Region	129	9.6	Low	1709	127.0	High	4729	351.5	High	3750	278.7	High
St. James's Hospital	Ireland	Dublin	38 (66.7)	19 (33.3)		1345402		Region	129	9.6	Low	1709	127.0	High	4729	351.5	High	3750	278.7	High
St Vincent's University Hospital	Ireland	Dublin	3 (100.0)			1345402		Region	129	9.6	Low	1709	127.0	High	4729	351.5	High	3750	278.7	High
Cork University Hospital	Ireland	Cork		16 (100.0)		542868		Region	48	8.8	Low	224	41.3	High	673	124.0	High	211	38.9	High
Beaumont Hospital	Ireland	Dublin		1 (100.0)		1345402		Region	129	9.6	Low	1709	127.0	High	4729	351.5	High	3750	278.7	High
University Hospital Galway	Ireland	Galway		11 (100.0)		258058		Region	12	4.7	Low	79	30.6	High	175	67.8	High	94	36.4	High
University Hospital Limerick	Ireland	Limerick		5 (100.0)		194899		Region	14	7.2	Low	80	41.0	High	249	127.8	High	221	113.4	High
University Hospital Waterford	Ireland	Waterford		5 (100.0)		116176		Region	7	6.0	Low	32	27.5	High	64	55.1	High	37	31.8	High
Santa Maria degli Angeli	Italy	Adria	10 (100.0)		244062			City	27	11.1	Low	109	44.7	High	155	63.5	High	136	55.7	High
University Hospital Umberto	Italy	Ancona	5 (26.3)	14 (73.7)	482886			City	267	55.3	High	849	175.8	High	531	110.0	High	163	33.8	High
Centro di Riferimento Oncologico di Aviano (CRO) IRCCS	Italy	Aviano	6 (100.0)		312794			City	42	13.4	Low	363	116.1	High	152	48.6	High	77	24.6	Low
Maggiore Hospital	Italy	Bologna	17 (65.4)	9 (34.6)	1017196			City	228	22.4	Low	1710	168.1	High	1440	141.6	High	1036	101.8	High
S.Orsola-Malpighi Hospital	Italy	Bologna	57 (32.2)	120 (67.8)	1017196			City	228	22.4	Low	1710	168.1	High	1440	141.6	High	1036	101.8	High
IRCCS Istituto Ortopedico Rizzoli	Italy	Bologna	21 (100.0)		1017196			City	228	22.4	Low	1710	168.1	High	1440	141.6	High	1036	101.8	High
Azienda Ospedaliera Universitaria Careggi	Italy	Firenze	24 (39.3)	37 (60.7)	1012388			City	157	15.5	Low	925	91.4	High	1285	126.9	High	748	73.9	High

IRCCS Ospedale Policlinico San Martino	Italy	Genoa	2 (2.1)	94 (97.9)	862175			City	274	31.8	High	821	95.2	High	2392	277.4	High	1129	130.9	High
P.O."Vito Fazzi"	Italy	Lecce	2 (4.4)	43 (95.6)	802807			City	38	4.7	Low	265	33.0	High	123	15.3	Low	61	7.6	Low
Fondazione IRCCS Istituto Nazionale dei Tumori	Italy	Milano	441 (99.8)	1 (0.2)	3259835			City	1720	52.8	High	7161	219.7	High	5764	176.8	High	4662	143.0	High
Istituto Europeo Oncologico	Italy	Milan	3 (100.0)		3259835			City	1720	52.8	High	7161	219.7	High	5764	176.8	High	4662	143.0	High
Colorectal Surgical Oncology Unit - Istituto Nazionale Tumori Fondazione, Pascale-I.R.C.C.S.	Italy	naples	1 (100.0)		3128700			City	175	5.6	Low	865	27.6	High	973	31.1	High	397	12.7	Low
HPB Surgical Oncology Unit - Istituto Nazionale Tumori Fondazione, Pascale-I.R.C.C.S.	Italy	naples	10 (100.0)		3128700			City	175	5.6	Low	865	27.6	High	973	31.1	High	397	12.7	Low
Ospedale S. Leonardo - ASL Napoli 3 sud, Castellammare di Stabia	Italy	Naples	1 (33.3)	2 (66.7)	3128700			City	175	5.6	Low	865	27.6	High	973	31.1	High	397	12.7	Low
Arcispedale Santa Maria Nuova	Italy	Reggio Emilia	3 (60.0)	2 (40.0)	531942			City	181	34.0	High	2122	398.9	High	1675	314.9	High	678	127.5	High
Ospedale Di Rho - ASST Rhodense	Italy	Rho	2 (100.0)		3259836			City	1720	52.8	High	7161	219.7	High	5764	176.8	High	4662	143.0	High
Fondazione Policlinico Universitario Agostino Gemelli	Italy	Rome	1 (1.0)	96 (99.0)	4336251			City	348	8.0	Low	1832	42.2	High	1479	34.1	High	1091	25.2	High
policlinico universitario campus bio medico of rome	Italy	rome	1 (5.9)	16 (94.1)	4336251			City	348	8.0	Low	1832	42.2	High	1479	34.1	High	1091	25.2	High
Valtiberina	Italy	Sansepolcro	1 (100.0)		343676			City	41	11.9	Low	291	84.7	High	190	55.3	High	102	29.7	High
Azienda Ospedaliera Universitaria Integrata di Verona	Italy	Verona	23 (85.2)	4 (14.8)	923664			City	335	36.3	High	1777	192.4	High	1537	166.4	High	1017	110.1	High
Ospedale di Circolo, University of Insubria, University Hospital of Varese, ASST Sette Laghi, Regione Lombardia	Italy	Varese Lombardy	23 (88.5)	3 (11.5)	889410			City	180	20.2	Low	709	79.7	High	991	111.4	High	783	88.0	High
Ospedali Riuniti di Ancona	Italy	Ancona		1 (100.0)	482886			City	267	55.3	High	849	175.8	High	531	110.0	High	163	33.8	High
Ospedale Regionale Umberto Parini	Italy	Aosta		3 (100.0)	34800			City	57	163.8	High	571	1640.8	High	330	948.3	High	170	488.5	High
Papa Giovanni XXIII Hospital	Italy	Bergamo		9 (100.0)	1112187			City	3306	297.3	High	5387	484.4	High	1669	150.1	High	841	75.6	High
S.Orsola-Malpighi Hospital	Italy	Bologna		6 (100.0)	1017197			City	228	22.4	Low	1710	168.1	High	1440	141.6	High	1036	101.8	High
St. Moritz Hospital	Italy	Bolzano		5 (100.0)	530009			City	203	38.3	High	1167	220.2	High	853	160.9	High	294	55.5	High
ASST Spedali Civili, Ospedale di Brescia	Italy	Brescia		10 (100.0)	1265964			City	2459	194.2	High	5894	465.6	High	2820	222.8	High	1674	132.2	High
Ospedale Vittorio Emanuele III	Italy	Carate Brianza (MB)		1 (100.0)	871735			City	321	36.8	High	2135	244.9	High	1416	162.4	High	826	94.8	High
Santa Croce Hospital	Italy	Cuneo		23 (100.0)	590309			City	61	10.3	Low	670	113.5	High	1060	179.6	High	695	117.7	High
Azienda Ospedaliero Universitaria San'Anna	Italy	Ferrara		44 (100.0)	350238			City	34	9.7	Low	286	81.7	High	329	93.9	High	272	77.7	High
Ospedale San Giovanni di Dio	Italy	Firenze		20 (100.0)	1012388			City	157	15.5	Low	925	91.4	High	1285	126.9	High	748	73.9	High
Ospedali Riuniti Azienda Ospedaliera Universitaria	Italy	Foggia		15 (100.0)	627102			City	62	9.9	Low	395	63.0	High	299	47.7	High	288	45.9	High

Ospedale Maggiore di Lodi	Italy	Lodi		1 (100.0)	229741			City	1083	471.4	High	796	346.5	High	471	205.0	High	379	165.0	High
ASST Mantua	Italy	Mantova		9 (100.0)	413663			City	338	81.7	High	1349	326.1	High	967	233.8	High	520	125.7	High
Fondazione IRCCS Ca' Granda - ospedale Maggiore Policlinico	Italy	Milan		19 (100.0)	3259835			City	1720	52.8	High	7161	219.7	High	5764	176.8	High	4662	143.0	High
ASST Santi Paolo e Carlo	Italy	Milan		1 (100.0)	3259835			City	1720	52.8	High	7161	219.7	High	5764	176.8	High	4662	143.0	High
Ospedale Fatebenefratelli e Oftalmico	Italy	Milan		1 (100.0)	3259835			City	1720	52.8	High	7161	219.7	High	5764	176.8	High	4662	143.0	High
Ospedale Luigi Sacco Milano	Italy	Milan		17 (100.0)	3259835			City	1720	52.8	High	7161	219.7	High	5764	176.8	High	4662	143.0	High
San Raffaele Scientific Institute, Milan	Italy	Milan		4 (100.0)	3259835			City	1720	52.8	High	7161	219.7	High	5764	176.8	High	4662	143.0	High
Humanitas Research Hospital	Italy	Milan		55 (100.0)	3259835			City	1720	52.8	High	7161	219.7	High	5764	176.8	High	4662	143.0	High
Regina Montis Regalis Hospital	Italy	Mondovì		4 (100.0)	590309			City	61	10.3	Low	670	113.5	High	1060	179.6	High	695	117.7	High
Ospedale San Gerardo	Italy	Monza		47 (100.0)	871735			City	321	36.8	High	2135	244.9	High	1416	162.4	High	826	94.8	High
Federico II University of Naples	Italy	Naples		3 (100.0)	3128702			City	175	5.6	Low	865	27.6	High	973	31.1	High	397	12.7	Low
ospedale del mare	Italy	Naples		19 (100.0)	3128702			City	175	5.6	Low	865	27.6	High	973	31.1	High	397	12.7	Low
Azienda Ospedaliero Universitaria Maggiore della Carità	Italy	Novara		3 (100.0)	373081			City	71	19.0	Low	726	194.6	High	911	244.2	High	583	156.3	High
Azienda Ospedaliera di Padova	Italy	Padova		2 (100.0)	938957			City	577	61.5	High	1606	171.0	High	1186	126.3	High	401	42.7	High
Azienda Ospedaliera, Ospedali Riuniti Villa Sofia, Cervello	Italy	Palermo		5 (100.0)	1249533			City	30	2.4	Low	229	18.3	Low	131	10.5	Low	100	8.0	Low
Policlinico Paolo Giaccone di Palermo	Italy	Palermo		5 (100.0)	1249533			City	30	2.4	Low	229	18.3	Low	131	10.5	Low	100	8.0	Low
Azienda Ospedaliero-Universitaria di Parma	Italy	Parma		37 (100.0)	449191			City	627	139.6	High	1271	283.0	High	683	152.1	High	541	120.4	High
G. Da Saliceto	Italy	Piacenza		6 (100.0)	286997			City	874	304.5	High	1623	565.5	High	588	204.9	High	839	292.3	High
Edoardo Agnelli	Italy	Pinerolo		2 (100.0)	2308409			City	348	15.1	Low	4096	177.4	High	4201	182.0	High	4442	192.4	High
Azienda Ospedaliero Universitaria Pisana	Italy	Pisa		11 (100.0)	421642			City	71	16.8	Low	400	94.9	High	262	62.1	High	114	27.0	High
Policlinico Umberto I	Italy	Rome		10 (100.0)	4336251			City	348	8.0	Low	1832	42.2	High	1479	34.1	High	1091	25.2	High
Ospedale San Filippo Neri	Italy	Rome		7 (100.0)	4336251			City	348	8.0	Low	1832	42.2	High	1479	34.1	High	1091	25.2	High
Cliniche San Pietro, A.O.U. Sassari	Italy	Sassari		40 (100.0)	493357			City	35	7.1	Low	451	91.4	High	277	56.1	High	73	14.8	Low
Mauriziano Hospital	Italy	Torino		1 (100.0)	2308409			City	348	15.1	Low	4096	177.4	High	4201	182.0	High	4442	192.4	High
Ca' Foncello	Italy	Treviso		2 (100.0)	884353			City	378	42.7	High	1109	125.4	High	511	57.8	High	478	54.1	High
ASST Vimercate	Italy	Vimercate		1 (100.0)	871735			City	321	36.8	High	2135	244.9	High	1416	162.4	High	826	94.8	High
National Cancer Center Hospital	Japan	Tokyo		14 (100.0)			126150000	Country	575	0.5	Low	1364	1.1	Low	6404	5.1	Low	5699	4.5	Low
King Hussein Cancer Center	Jordan	Amman	141 (100.0)				10655387	Country	12	0.1	Low	262	2.5	Low	127	1.2	Low	52	0.5	Low
Al-Basheer Hospital	Jordan	Amman		14 (100.0)			10655387	Country	12	0.1	Low	262	2.5	Low	127	1.2	Low	52	0.5	Low
King Abdullah University Hospital	Jordan	Ar Ramtha		4 (100.0)			10655387	Country	12	0.1	Low	262	2.5	Low	127	1.2	Low	52	0.5	Low

National cancer institute	Libya	Sabratha	8 (100.0)				6871287	Country	4	0.1	Low	4	0.1	Low	27	0.4	Low	26	0.4	Low
Alkhadra Hospital	Libya	Tripoli	2 (100.0)				6871287	Country	4	0.1	Low	4	0.1	Low	27	0.4	Low	26	0.4	Low
Al-jalaa hospital	Libya	Benghazi		1 (100.0)			6871287	Country	4	0.1	Low	4	0.1	Low	27	0.4	Low	26	0.4	Low
Joseph Ravoahangy Andrianavalona Hospital	Madagascar	Antananarivo		2 (100.0)			26262313	Country	23	0.1	Low	23	0.1	Low	64	0.2	Low	18	0.1	Low
Hospital Universiti Sains Malaysia	Malaysia	Kota Bharu	7 (100.0)			2001000		Region	18	0.9	Low	113	5.6	Low	23	1.1	Low	1	0.0	Low
Queen Elizabeth Hospital	Malaysia	Kota Kinabalu	2 (100.0)			3900000		Region	57	1.5	Low	149	3.8	Low	79	2.0	Low	30	0.8	Low
University Malaya Medical Centre	Malaysia	Kuala Lumpur	3 (8.1)	34 (91.9)	1790000			City	100	5.6	Low	324	18.1	Low	496	27.7	High	306	17.1	Low
Hospital Kuala Lumpur	Malaysia	Kuala Lumpur	4 (28.6)	10 (71.4)	1790000			City	100	5.6	Low	324	18.1	Low	496	27.7	High	306	17.1	Low
Bintulu	Malaysia	Bintulu		1 (100.0)		2810000		Region	21	0.7	Low	135	4.8	Low	215	7.7	Low	136	4.8	Low
Hospital San Ángel Inn Chapultepec	Mexico	Mexico City	1 (100.0)				128649565	Country	49	0.0	Low	1162	0.9	Low	4632	3.6	Low	13377	10.4	Low
Instituto Nacional de Ciencias Médicas y Nutrición "Salvador Zubirán"	Mexico	Mexico City	16 (84.2)	3 (15.8)			128649565	Country	49	0.0	Low	1162	0.9	Low	4632	3.6	Low	13377	10.4	Low
ABC Medical Center	Mexico	Mexico City		7 (100.0)			128649565	Country	49	0.0	Low	1162	0.9	Low	4632	3.6	Low	13377	10.4	Low
Institut National d'Oncologie	Morocco	Rabat	116 (100.0)				36472000	Country	28	0.1	Low	589	1.6	Low	1407	3.9	Low	2399	6.6	Low
Antoni van Leeuwenhoek ziekenhuis	Netherlands	Amsterdam	42 (100.0)				17424978	Country	1129	6.5	Low	11460	65.8	High	15558	89.3	High	11163	64.1	High
Spaarne Gasthuis	Netherlands	Haarlem	88 (98.9)	1 (1.1)			17424978	Country	1129	6.5	Low	11460	65.8	High	15558	89.3	High	11163	64.1	High
Amsterdam UMC, University of Amsterdam	Netherlands	Amsterdam		1 (100.0)			17424978	Country	1129	6.5	Low	11460	65.8	High	15558	89.3	High	11163	64.1	High
Gelre ziekenhuis	Netherlands	Apeldoorn		22 (100.0)			17424978	Country	1129	6.5	Low	11460	65.8	High	15558	89.3	High	11163	64.1	High
Slingeland Ziekenhuis	Netherlands	Doetinchem		12 (100.0)			17424978	Country	1129	6.5	Low	11460	65.8	High	15558	89.3	High	11163	64.1	High
VieCuri Medisch Centrum	Netherlands	Venlo		9 (100.0)			17424978	Country	1129	6.5	Low	11460	65.8	High	15558	89.3	High	11163	64.1	High
Ekiti State University Teaching Hospital	Nigeria	Ado-Ekiti		1 (100.0)			204630269	Country	1	0.0	Low	109	0.1	Low	232	0.1	Low	1189	0.6	Low
University of Ilorin Teaching Hospital	Nigeria	Ilorin		2 (100.0)			204630269	Country	1	0.0	Low	109	0.1	Low	232	0.1	Low	1189	0.6	Low
Ahmadu Bello University Teaching Hospital	Nigeria	Zaria		3 (100.0)			204630269	Country	1	0.0	Low	109	0.1	Low	232	0.1	Low	1189	0.6	Low
Khoula Hospital	Oman	Muscat		1 (100.0)			4829473	Country	16	0.3	Low	170	3.5	Low	718	14.9	Low	1364	28.2	High
Cancer Foundation Hospital	Pakistan	Karachi	7 (100.0)			47886051		Region	30	0.1	Low	642	1.3	Low	992	2.1	Low	4385	9.2	Low
The Pakistan Institute of Medical Sciences	Pakistan	Islamabad		1 (100.0)		2006572		Region	4	0.2	Low	50	2.5	Low	86	4.3	Low	203	10.1	Low
Dr Ruth K.M. Pfau Civil Hospital	Pakistan	Karachi		5 (100.0)		47886051		Region	30	0.1	Low	642	1.3	Low	992	2.1	Low	4385	9.2	Low
Patel Hospital	Pakistan	Karachi		1 (100.0)		47886051		Region	30	0.1	Low	642	1.3	Low	992	2.1	Low	4385	9.2	Low
Services Hospital Lahore	Pakistan	Lahore		6 (100.0)		110012442		Region	1	0.0	Low	707	0.6	Low	2435	2.2	Low	3197	2.9	Low
Instituto Regional de Enfermedades Neoplásicas del Sur	Peru	Arequipa	3 (100.0)				32824358	Country	71	0.2	Low	994	3.0	Low	10410	31.7	High	25501	77.7	High

Independent Public Teaching Hospital No 1 in Lublin	Poland	Lublin		19 (100.0)		2147746		Region	17	0.8	Low	115	5.4	Low	138	6.4	Low	90	4.2	Low
IPO Coimbra	Portugal	Coimbra	21 (100.0)			2327026		Region	11	0.5	Low	911	39.1	High	1716	73.7	High	760	32.7	High
Centro Hospitalar Cova da Beira	Portugal	Covilha	3 (100.0)			2327026		Region	11	0.5	Low	911	39.1	High	1716	73.7	High	760	32.7	High
Centro Hospitalar Universitário Lisboa Central	Portugal	Lisbon	5 (12.2)	36 (87.8)		2815853		Region	116	4.1	Low	1683	59.8	High	2303	81.8	High	1713	60.8	High
Instituto Português de Oncologia de Lisboa Francisco Gentil	Portugal	Lisboa	56 (100.0)			2815853		Region	116	4.1	Low	1683	59.8	High	2303	81.8	High	1713	60.8	High
IPO Lisboa	Portugal	Lisboa	35 (100.0)			2815853		Region	116	4.1	Low	1683	59.8	High	2303	81.8	High	1713	60.8	High
Centro Hospitalar Lisboa Norte	Portugal	Lisbon	2 (100.0)			2815853		Region	116	4.1	Low	1683	59.8	High	2303	81.8	High	1713	60.8	High
Hospital Beatriz Angelo	Portugal	Loures	1 (3.1)	31 (96.9)		2815853		Region	116	4.1	Low	1683	59.8	High	2303	81.8	High	1713	60.8	High
IPO Porto	Portugal	Porto	45 (97.8)	1 (2.2)		3689173		Region	103	2.8	Low	4344	117.7	High	6299	170.7	High	4339	117.6	High
Hospital de Torres Vedras - Centro Hospitalar do Oeste	Portugal	Torres Vedras	1 (100.0)			2327026		Region	11	0.5	Low	911	39.1	High	1716	73.7	High	760	32.7	High
Hospital Garcia de Orta	Portugal	Almada		2 (100.0)		2815853		Region	116	4.1	Low	1683	59.8	High	2303	81.8	High	1713	60.8	High
Hospital de Santo Espirito da ilha Terceira	Portugal	Angra do Heroismo		8 (100.0)		246772		Region	1	0.4	Low	48	19.5	Low	51	20.7	Low	27	10.9	Low
Centro Hospitalar e Universitário de Coimbra	Portugal	Coimbra		38 (100.0)		2327026		Region	11	0.5	Low	911	39.1	High	1716	73.7	High	760	32.7	High
Hospital Faro, Centro Hospitalar Universitario do Algarve	Portugal	Faro		20 (100.0)		451006		Region	10	2.2	Low	127	28.2	High	162	35.9	High	36	8.0	Low
Hospital da Horta, E.P.E.	Portugal	Horta		9 (100.0)		246772		Region	1	0.4	Low	48	19.5	Low	51	20.7	Low	27	10.9	Low
Hospital do Divino Espírito Santo	Portugal	Ponta Delgada		5 (100.0)		246772		Region	1	0.4	Low	48	19.5	Low	51	20.7	Low	27	10.9	Low
Centro Hospitalar do Tamega e Sousa	Portugal	Penafiel		13 (100.0)		3689173		Region	103	2.8	Low	4344	117.7	High	6299	170.7	High	4339	117.6	High
Centro Hospitalar Universitario do Algarve	Portugal	Portimao		21 (100.0)		451006		Region	10	2.2	Low	127	28.2	High	162	35.9	High	36	8.0	Low
Centro Hospital Universitário São João	Portugal	Porto		27 (100.0)		3689173		Region	103	2.8	Low	4344	117.7	High	6299	170.7	High	4339	117.6	High
Hospital do Litoral Alentejano	Portugal	Santiago do Cacém		6 (100.0)		758739		Region	0	0.0	Low	50	6.6	Low	105	13.8	Low	59	7.8	Low
Centro Hospitalar de Setúbal	Portugal	Setúbal		1 (100.0)		2815853		Region	116	4.1	Low	1683	59.8	High	2303	81.8	High	1713	60.8	High
Centro Hospitalar Tondela-Viseu	Portugal	Viseu		4 (100.0)		2327026		Region	11	0.5	Low	911	39.1	High	1716	73.7	High	760	32.7	High
Centro Hospitalar de Trás-os-Montes e Alto Douro, E.P.E.	Portugal	Vila Real		21 (100.0)		3689173		Region	103	2.8	Low	4344	117.7	High	6299	170.7	High	4339	117.6	High
Instituto Gineco Oncologico	Puerto Rico	San Juan		26 (100.0)			3193694	Country	5	0.2	Low	234	7.3	Low	735	23.0	Low	565	17.7	Low
CHU Reunion	Reunion	Saint Denis		1 (100.0)			859959	Country	9	1.0	Low	238	27.7	High	144	16.7	Low	29	3.4	Low
Coltea Clinical Hospital	Romania	Bucharest	1 (100.0)		1883425			City	38	2.0	Low	53	2.8	Low	319	16.9	Low	451	23.9	Low
Prof. Dr. Ion Chiricuta Institute of Oncology	Romania	Cluj-Napoca	11 (100.0)			691106		Region	2	0.3	Low	3	0.4	Low	109	15.8	Low	148	21.4	Low
Saint John Emergency Hospital	Romania	Bucharest		1 (100.0)	1883425			City	38	2.0	Low	53	2.8	Low	319	16.9	Low	451	23.9	Low
Emergency Clinical City Hospital	Romania	Timisoara		4 (100.0)		683540		Region	14	2.0	Low	2	0.3	Low	224	32.8	High	133	19.5	Low
Immanuel Kant Baltic Federal University, Regional Clinical Hospital	Russian Federation	Kaliningrad	1 (100.0)				14674509 8	Country	61	0.0	Low	2274	1.5	Low	22153	15.1	Low	8200 8	55.9	High
Moscow Research and Educational Center, Lomonosov Moscow State University	Russian Federation	Moscow	4 (100.0)				14674509 8	Country	61	0.0	Low	2274	1.5	Low	22153	15.1	Low	8200 8	55.9	High

Clinic of Coloproctology and Minimally Invasive Surgery, Sechenov Medical State University	Russian Federation	Moscow	2 (100.0)				146745098	Country	61	0.0	Low	2274	1.5	Low	22153	15.1	Low	82008	55.9	High
King faisal medical complex	Saudi Arabia	Taif	1 (100.0)				34218169	Country	118	0.3	Low	1445	4.2	Low	4299	12.6	Low	176	0.5	Low
aseer central hospital	Saudi Arabia	abha		7 (100.0)			34218169	Country	118	0.3	Low	1445	4.2	Low	4299	12.6	Low	16891	49.4	High
East Jeddah general hospital	Saudi Arabia	Jeddah		1 (100.0)			34218169	Country	118	0.3	Low	1445	4.2	Low	4299	12.6	Low	16891	49.4	High
King Abdulaziz University Hospital	Saudi Arabia	Jeddah		24 (100.0)			34218169	Country	118	0.3	Low	1445	4.2	Low	4299	12.6	Low	16891	49.4	High
King Fahad General Hospital	Saudi Arabia	Jeddah		2 (100.0)			34218169	Country	118	0.3	Low	1445	4.2	Low	4299	12.6	Low	16891	49.4	High
King Khalid Hospital	Saudi Arabia	Najran		10 (100.0)			34218169	Country	118	0.3	Low	1445	4.2	Low	4299	12.6	Low	16891	49.4	High
King Abdulaziz Medical City	Saudi Arabia	Riyadh		47 (100.0)			34218169	Country	118	0.3	Low	1445	4.2	Low	4299	12.6	Low	16891	49.4	High
King Khalid University Hospital	Saudi Arabia	Riyadh		19 (100.0)			34218169	Country	118	0.3	Low	1445	4.2	Low	4299	12.6	Low	16891	49.4	High
King Faisal Specialist Hospital	Saudi Arabia	Riyadh		16 (100.0)			34218169	Country	118	0.3	Low	1445	4.2	Low	4299	12.6	Low	16891	49.4	High
Clinic for Maxillofacial Surgery, School of Dental Medicine, University of Belgrade	Serbia	Belgrade	1 (100.0)				6963764	Country	48	0.7	Low	852	12.2	Low	3973	57.1	High	4136	59.4	High
Clinic for Gynecology and Obstetrics Narodni Front	Serbia	Belgrade	1 (50.0)	1 (50.0)			6963764	Country	48	0.7	Low	852	12.2	Low	3973	57.1	High	4136	59.4	High
Clinic for Gynecology and Obstetrics, Clinical Center of Serbia	Serbia	Belgrade	17 (100.0)				6963764	Country	48	0.7	Low	852	12.2	Low	3973	57.1	High	4136	59.4	High
Clinic for Digestive Surgery, Clinical Centre of Serbia	Serbia	Belgrade	61 (96.8)	2 (3.2)			6963764	Country	48	0.7	Low	852	12.2	Low	3973	57.1	High	4136	59.4	High
Centre for endocrine surgery, Clinical Centre of Serbia	Serbia	Belgrade	11 (100.0)				6963764	Country	48	0.7	Low	852	12.2	Low	3973	57.1	High	4136	59.4	High
Clinic for emergency surgery, Emergency centre, Clinical centre of Serbia	Serbia	Belgrade	6 (100.0)				6963764	Country	48	0.7	Low	852	12.2	Low	3973	57.1	High	4136	59.4	High
Clinic for Otorhinolaryngology and Maxillofacial Surgery, Clinical Center of Serbia	Serbia	Belgrade	16 (100.0)				6963764	Country	48	0.7	Low	852	12.2	Low	3973	57.1	High	4136	59.4	High
Institute for Oncology and Radiology of Serbia	Serbia	Belgrade	131 (99.2)	1 (0.8)			6963764	Country	48	0.7	Low	852	12.2	Low	3973	57.1	High	4136	59.4	High
National University Hospital	Singapore	Singapore	1 (0.7)	146 (99.3)			5703600	Country	124	2.2	Low	700	12.3	Low	2773	48.6	High	12470	218.6	High
University Hospital Bratislava	Slovak Republic	Bratislava		3 (100.0)			5450421	Country	61	1.1	Low	339	6.2	Low	577	10.6	Low	426	7.8	Low
Groote Schuur Hospital	South Africa	Cape Town		22 (100.0)		5822734		Region	14	0.2	Low	311	5.3	Low	332	5.7	Low	1685	28.9	High
Hospital Clinic Barcelona	Spain	Barcelona	1 (2.4)	40 (97.6)		7522596		Region	700	9.3	Low	19088	253.7	High	17363	230.8	High	11953	158.9	High
Vall d'Hebron University Hospital	Spain	Barcelona	1 (9.1)	10 (90.9)		7522596		Region	700	9.3	Low	19088	253.7	High	17363	230.8	High	11953	158.9	High

Hospital del Mar	Spain	Barcelona	3 (17.6)	14 (82.4)		7522596		Region	700	9.3	Low	19088	253.7	High	17363	230.8	High	11953	158.9	High
Hospital Urduliz	Spain	Bizkaia	1 (50.0)	1 (50.0)		2189534		Region	621	28.4	High	6208	283.5	High	4952	226.2	High	2681	122.4	High
Getafe University Hospital	Spain	Getafe	13 (41.9)	18 (58.1)		6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High
12 de Octubre University Hospital	Spain	Madrid	1 (12.5)	7 (87.5)		6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High
Hospital Universitario de la Princesa	Spain	Madrid	1 (10.0)	9 (90.0)		6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High
Hospital Universitario de Torrejón de Ardoz	Spain	Madrid	7 (38.9)	11 (61.1)		6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High
Hospital Universitario Principe de Asturias	Spain	Madrid	1 (8.3)	11 (91.7)		6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High
Hospital del Henares	Spain	Madrid	5 (100.0)			6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High
Hospital Universitario la Paz	Spain	Madrid	2 (6.7)	28 (93.3)		6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High
Infanta Sofía University Hospital	Spain	San Sebastian de Los Reyes	1 (7.7)	12 (92.3)		6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High
Hospital Universitario Donostia	Spain	San Sebastian	1 (11.1)	8 (88.9)		6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High
Hospital Universitario Río Hortega	Spain	Valladolid	6 (100.0)			2447519		Region	289	11.8	Low	6513	266.1	High	7533	307.8	High	4505	184.1	High
Hospital Universitario y Politécnico La Fe	Spain	Valencia	2 (5.4)	35 (94.6)		5003769		Region	394	7.9	Low	5514	110.2	High	3693	73.8	High	1705	34.1	High
Álvaro Cunqueiro Hospital	Spain	Vigo	22 (64.7)	12 (35.3)		2701743		Region	195	7.2	Low	4187	155.0	High	3441	127.4	High	1766	65.4	High
Cruces Hospital	Spain	Barakaldo		48 (100.0)		2189534		Region	621	28.4	High	6208	283.5	High	4952	226.2	High	2681	122.4	High
Consorci Sanitari de Terrassa	Spain	Barcelona		6 (100.0)		7522597		Region	700	9.3	Low	19088	253.7	High	17363	230.8	High	11953	158.9	High
Comarcal Alt Penedés	Spain	Barcelona		1 (100.0)		7522597		Region	700	9.3	Low	19088	253.7	High	17363	230.8	High	11953	158.9	High
Hospital General Universitario de Ciudad Real	Spain	Ciudad Real		10 (100.0)		2041631		Region	398	19.5	Low	6480	317.4	High	8104	396.9	High	3188	156.1	High
Hospital Don Benito-Villanueva	Spain	Don Benito (Badajoz)		9 (100.0)		1087778		Region	89	8.2	Low	1568	144.1	High	1202	110.5	High	475	43.7	High
Hospital Universitario de Galdakao	Spain	Galdakao-Usansolo		1 (100.0)		2189534		Region	621	28.4	High	6208	283.5	High	4952	226.2	High	2681	122.4	High
Hospital de Cabueñes	Spain	Gijón		23 (100.0)		1018706		Region	204	20.0	Low	1145	112.4	High	848	83.2	High	352	34.6	High
Bellvitge University Hospital	Spain	L'Hospitalet de Llobregat		1 (100.0)		7522596		Region	700	9.3	Low	19088	253.7	High	17363	230.8	High	11953	158.9	High
Severo Ochoa University Hospital	Spain	Leganés		19 (100.0)		6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High
Fundación Jimenez Diaz University Hospital	Spain	Madrid		4 (100.0)		6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High
Hospital General Universitario Gregorio Marañón	Spain	Madrid		32 (100.0)		6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High

Hospital Clínico de Madrid	Spain	Madrid		26 (100.0)		6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High
Hospital Universitario del Sureste	Spain	Madrid		1 (100.0)		6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High
Hospital Mateu Orfila	Spain	Mahon		7 (100.0)		1107220		Region	90	8.1	Low	1058	95.6	High	506	45.7	High	311	28.1	High
Hospital Sant Joan de Déu Althaia	Spain	Manresas		16 (100.0)		7522596		Region	700	9.3	Low	19088	253.7	High	17363	230.8	High	11953	158.9	High
Hospital Universitario de Móstoles	Spain	Móstoles		3 (100.0)		6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High
Rey Juan Carlos University Hospital	Spain	Móstoles		1 (100.0)		6661949		Region	3515	52.8	High	25675	385.4	High	20854	313.0	High	13922	209.0	High
Hospital General Reina Sofía	Spain	Murcia		52 (100.0)		1478509		Region	71	4.8	Low	964	65.2	High	557	37.7	High	151	10.2	Low
Hospital Universitario Virgen de la Arrixaca	Spain	Murcia		1 (100.0)		1478509		Region	71	4.8	Low	964	65.2	High	557	37.7	High	151	10.2	Low
Hospital Santa Bárbara	Spain	Puertollano		1 (100.0)		2041631		Region	398	19.5	Low	6480	317.4	High	8104	396.9	High	3188	156.1	High
Hospital Universitari Sant Joan	Spain	Reus		2 (100.0)		7522596		Region	700	9.3	Low	19088	253.7	High	17363	230.8	High	11953	158.9	High
Marqués de Valdecilla University Hospital	Spain	Santander		69 (100.0)		580229		Region	41	7.1	Low	1155	199.1	High	632	108.9	High	551	95.0	High
Hospital Universitario Virgen Macarena	Spain	Seville		9 (100.0)		8388107		Region	1538	18.3	Low	5838	69.6	High	4415	52.6	High	1936	23.1	Low
Hospital Universitari de Tarragona Joan XXIII	Spain	Tarragona		14 (100.0)		7522596		Region	700	9.3	Low	19088	253.7	High	17363	230.8	High	11953	158.9	High
Hospital Clínico Universitario de Valencia	Spain	Valencia		18 (100.0)		5003769		Region	394	7.9	Low	5514	110.2	High	3693	73.8	High	1705	34.1	High
Consorcio Hospital General Universitario	Spain	Valencia		1 (100.0)		5003769		Region	394	7.9	Low	5514	110.2	High	3693	73.8	High	1705	34.1	High
Hospital Clínico Universitario de Valladolid	Spain	Valladolid		13 (100.0)		2447519		Region	289	11.8	Low	6513	266.1	High	7533	307.8	High	4505	184.1	High
Royo Villanova	Spain	Zaragoza		13 (100.0)		1308563		Region	163	12.5	Low	2317	177.1	High	2075	158.6	High	954	72.9	High
Hospital Clinico Universitario Zaragoza	Spain	Zaragoza		7 (100.0)		1308563		Region	163	12.5	Low	2317	177.1	High	2075	158.6	High	954	72.9	High
Hospital Universitario Miguel Servet	Spain	Zaragoza		50 (100.0)		1308563		Region	163	12.5	Low	2317	177.1	High	2075	158.6	High	954	72.9	High
Umea University Hospital	Sweden	Umea	1 (2.2)	44 (97.8)		268067		Region	13	4.8	Low	49	18.3	Low	141	52.6	High	121	45.1	High
Karolinska University Hospital	Sweden	Stockholm		4 (100.0)		2377081		Region	370	15.6	Low	1751	73.7	High	2976	125.2	High	3057	128.6	High
South General Hospital	Sweden	Stockholm		6 (100.0)		2377081		Region	370	15.6	Low	1751	73.7	High	2976	125.2	High	3057	128.6	High
Ente Ospedaliero Cantonale	Switzerland	Ticino (Lugano, Bellinzona, Locarno, Mendrisio)	10 (100.0)			353343		Region	254	71.9	High	1800	509.4	High	816	230.9	High	283	80.1	High
University Hospital Bern, Inselspital	Switzerland	BERN		5 (100.0)		1034977		Region	58	5.6	Low	778	75.2	High	540	52.2	High	268	25.9	High
Hopital de Pourtales	Switzerland	Neuchatel		3 (100.0)		176850		Region	31	17.5	Low	328	185.5	High	210	118.7	High	73	41.3	High

Kantonsspital Winterthur	Switzerland	Winterthur		19 (100.0)		1520968		Region	141	9.3	Low	2073	136.3	High	1168	76.8	High	359	23.6	Low
Baskent university	Turkey	Ankara	20 (100.0)				83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Koç University Medical School	Turkey	Istanbul	11 (39.3)	17 (60.7)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Istanbul universty - Cerrahpaşa Medical faculty	Turkey	Istanbul	8 (33.3)	16 (66.7)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
University of Health Sciences Tepecik Training and Research Hospital	Turkey	İzmir	46 (93.9)	3 (6.1)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Kocaeli University Teaching Hospital	Turkey	Kocaeli	13 (92.9)	1 (7.1)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Mus State Hospital	Turkey	mus	1 (2.4)	41 (97.6)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Sakarya Faculty Of Medicine	Turkey	Sakarya	45 (80.4)	11 (19.6)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Samsun Training and Research Hospital	Turkey	Samsun	2 (8.7)	21 (91.3)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Adana Baskent University	Turkey	Adana		9 (100.0)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Ankara CITY Hospital	Turkey	Ankara		27 (100.0)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Gazi University Medical Faculty Hospital	Turkey	Ankara		7 (100.0)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Hacettepe university hospital	Turkey	Ankara		23 (100.0)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Acibadem Altunizade Hospital	Turkey	Istanbul		2 (100.0)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Acibadem Atakent Hospital	Turkey	Istanbul		17 (100.0)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Acibadem Maslak Hospital	Turkey	Istanbul		14 (100.0)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Kanuni Sultan Suleyman Training and Research Hospital	Turkey	Istanbul		16 (100.0)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Sisli Hamidiye Etfal Training and Research Hospital	Turkey	Istanbul		13 (100.0)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Sehit Prof.Dr. İlhan Varank Training and Research Hospital	Turkey	Istanbul		6 (100.0)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Van yuzuncu yil university, medical faculty	Turkey	Van		1 (100.0)			83154997	Country	18	0.0	Low	13513	16.3	Low	55861	67.2	High	50812	61.1	High
Aberdeen Royal Infirmary	UK	Aberdeen	5 (8.6)	53 (91.4)		585700		Region	12	2.0	Low	74	12.6	Low	271	46.3	High	477	81.4	High
Antrim Area Hospital- Northern Health and Social Care Trust	Northen Ireland	Antrim	1 (16.7)	5 (83.3)			1893667	Country	44	2.3	Low	541	28.6	High	1502	79.3	High	1448	76.5	High
University Hospital Ayr	UK	Ayr	1 (4.3)	22 (95.7)		369360		Region	6	1.6	Low	171	46.3	High	280	75.8	High	305	82.6	High
City Hospital, Dudley Road	UK	Birmingham	7 (30.4)	16 (69.6)	1141816			City	55	4.8	Low	1009	88.4	High	1090	95.5	High	758	66.4	High
Heartlands Hospital	UK	Birmingham	6 (28.6)	15 (71.4)	1141816			City	55	4.8	Low	1009	88.4	High	1090	95.5	High	758	66.4	High
Queen Elizabeth Hospital Birmingham	UK	Birmingham	24 (29.6)	57 (70.4)	1141816			City	55	4.8	Low	1009	88.4	High	1090	95.5	High	758	66.4	High
Sandwell General Hospital	UK	Birmingham	1 (12.5)	7 (87.5)	1141816			City	55	4.8	Low	1009	88.4	High	1090	95.5	High	758	66.4	High

Royal Orthopaedic Hospital	UK	Birmingham	18 (100.0)		1141816			City	55	4.8	Low	1009	88.4	High	1090	95.5	High	758	66.4	High
Royal Blackburn Hospital	UK	Blackburn	2 (5.6)	34 (94.4)	149696			City	23	15.4	Low	23	15.4	Low	170	113.6	High	114	76.2	High
Addenbrooke's Hospital	UK	Cambridge	2 (2.9)	67 (97.1)	124798			City	5	4.0	Low	33	26.4	High	75	60.1	High	62	49.7	High
Royal Papworth Hospital	UK	Cambridge	54 (94.7)	3 (5.3)	124798			City	5	4.0	Low	33	26.4	High	75	60.1	High	62	49.7	High
University Hospital Llandough	UK	Cardiff	42 (100.0)			496413		Region	15	3.0	Low	525	105.8	High	1136	228.8	High	594	119.7	High
University Hospital of Wales	UK	Cardiff	2 (18.2)	9 (81.8)		496413		Region	15	3.0	Low	525	105.8	High	1136	228.8	High	594	119.7	High
University Hospitals Coventry and Warwickshire NHS trusts	UK	Coventry	4 (5.3)	71 (94.7)	371521			City	13	3.5	Low	194	52.2	High	285	76.7	High	182	49.0	High
Royal Derby Hospital	UK	Derby	3 (20.0)	12 (80.0)	248700			City	11	4.4	Low	200	80.4	High	181	72.8	High	111	44.6	High
Epsom & St Helier University Hospitals NHS Trust	UK	Epsom	7 (70.0)	3 (30.0)	79928			City	3	3.8	Low	62	77.6	High	103	128.9	High	29	36.3	High
Royal Devon and Exeter Hospital	UK	Exeter	2 (4.8)	40 (95.2)	131405			City	6	4.6	Low	26	19.8	Low	83	63.2	High	40	30.4	High
Queen Elizabeth Hospital	UK	Gateshead	4 (23.5)	13 (76.5)	202508			City	2	1.0	Low	100	49.4	High	436	215.3	High	317	156.5	High
Golden Jubilee National Hospital	UK	Glasgow	60 (100.0)			1183120		Region	39	3.3	Low	508	42.9	High	1114	94.2	High	1098	92.8	High
Royal Surrey County Hospital	UK	Guildford	13 (12.3)	93 (87.7)	147889			City	14	9.5	Low	53	35.8	High	176	119.0	High	85	57.5	High
Royal Free Hospital	UK	London (Camden)	6 (30.0)	14 (70.0)	270029			City	33	12.2	Low	211	78.1	High	246	91.1	High	95	35.2	High
Northwick Park Hospital	UK	London (Harrow)	3 (42.9)	4 (57.1)	251160			City	39	15.5	Low	352	140.1	High	344	137.0	High	203	80.8	High
Hull University Teaching Hospitals NHS Trust	UK	Hull	115 (92.7)	9 (7.3)	259778			City	10.5	4.0	Low	10.5	4.0	Low	200	77.0	High	280	107.8	High
St James's University Hospital Leeds	UK	Leeds	4 (3.4)	112 (96.6)	793139			City	14	1.8	Low	224	28.2	High	587	74.0	High	629	79.3	High
Glenfield Hospital	UK	Leicester	18 (100.0)		329839			City	5	1.5	Low	129	39.1	High	313	94.9	High	238	72.2	High
Leicester Royal Infirmary	UK	Leicester	7 (100.0)		329839			City	5	1.5	Low	129	39.1	High	313	94.9	High	238	72.2	High
Aintree University Hospital	UK	Liverpool	1 (2.5)	39 (97.5)	498042			City	16	3.2	Low	331	66.5	High	730	146.6	High	373	74.9	High
Liverpool Heart and Chest Hospital	UK	Liverpool	23 (100.0)		498042			City	16	3.2	Low	331	66.5	High	730	146.6	High	373	74.9	High
Altnagelvin Area Hospital	Northen Ireland	Londonderry	7 (21.2)	26 (78.8)			1893667	Country	44	2.3	Low	541	28.6	High	1502	79.3	High	1448	76.5	High
Chelsea and Westminster Hospital	UK	London (Kensington and Chelsea)	2 (50.0)	2 (50.0)	156129			City	54	34.6	High	171	109.5	High	165	105.7	High	73	46.8	High
Guy's Hospital	UK	London (Southwark)	16 (88.9)	2 (11.1)	317256			City	72	22.7	Low	470	148.1	High	511	161.1	High	156	49.2	High
Hammersmith Hospital	UK	London (Hammersmith and Fulham)	23 (100.0)		185143			City	29	15.7	Low	184	99.4	High	233	125.8	High	176	95.1	High
Royal London Hospital	UK	London (Tower Hamlets)	8 (66.7)	4 (33.3)	324745			City	25	7.7	Low	235	72.4	High	277	85.3	High	69	21.2	Low
St George's Hospital	UK	London (Wandsworth)	5 (41.7)	7 (58.3)	329677			City	65	19.7	Low	393	119.2	High	358	108.6	High	125	37.9	High

St Thomas' Hospital	UK	London (Lambeth)	4 (100.0)		326034			City	67	20.6	Low	482	147.8	High	448	137.4	High	151	46.3	High
University College London Hospital at Westmoreland Street	UK	London (City of Westminster)	3 (100.0)		261317			City	75	28.7	High	251	96.1	High	218	83.4	High	79	30.2	High
University College London Hospital	UK	London (City of Westminster)	22 (88.0)	3 (12.0)	261317			City	75	28.7	High	251	96.1	High	218	83.4	High	79	30.2	High
Royal Lancaster Infirmary	UK	Morecambe	1 (20.0)	4 (80.0)	146038			City	5	3.4	Low	223	152.7	High	333	228.0	High	159	108.9	High
Royal Victoria Infirmary	UK	Newcastle upon Tyne	86 (100.0)		302820			City	13	4.3	Low	216	71.3	High	445	147.0	High	260	85.9	High
Royal Gwent Hospital	UK	Newport	2 (5.4)	35 (94.6)		561400		Region	59	10.5	Low	775	138.0	High	867	154.4	High	445	79.3	High
Northampton General Hospital	UK	Northampton	1 (14.3)	6 (85.7)	224610			City	6	2.7	Low	91	40.5	High	225	100.2	High	59	26.3	High
Nottingham City Hospital	UK	Nottingham	115 (69.7)	50 (30.3)	321500			City	17	5.3	Low	115	35.8	High	218	67.8	High	174	54.1	High
Queens Medical Centre	UK	Nottingham	5 (20.8)	19 (79.2)	321500			City	17	5.3	Low	115	35.8	High	218	67.8	High	174	54.1	High
Northumbria NHS Hospital Trust	UK	North Shields	1 (5.0)	19 (95.0)	207913			City	7	3.4	Low	88	42.3	High	263	126.5	High	126	60.6	High
Robert Jones and Agnes Hunt Orthopaedic Hospital	UK	Oswestry	10 (100.0)			323136		Region	26	8.0	Low	99	30.6	High	178	55.1	High	217	67.2	High
John Radcliffe Hospital	UK	Oxford	85 (77.3)	25 (22.7)	154600			City	14	9.1	Low	76	49.2	High	272	175.9	High	1236	799.5	High
Nuffield Orthopaedic Centre	UK	Oxford	11 (100.0)		154600			City	14	9.1	Low	76	49.2	High	272	175.9	High	1236	799.5	High
Poole Hospital	UK	Poole	1 (20.0)	4 (80.0)		772268		Region	8	1.0	Low	73	9.5	Low	148	19.2	Low	90	11.7	Low
Royal Preston Hospital	UK	Preston	1 (2.9)	34 (97.1)	141818			City	3	2.1	Low	56	39.5	High	160	112.8	High	126	88.8	High
Queen's Hospital Romford	UK	London (Havering)	2 (50.0)	2 (50.0)	259552			City	13	5.0	Low	163	62.8	High	353	136.0	High	111	42.8	High
Royal Hallamshire Hospital	UK	Sheffield	35 (92.1)	3 (7.9)	584853			City	36	6.2	Low	730	124.8	High	1551	265.2	High	631	107.9	High
Royal National Orthopaedic Hospital	UK	London (Harrow)	10 (100.0)		251160			City	39	15.5	Low	352	140.1	High	344	137.0	High	203	80.8	High
Stepping Hill Hospital	UK	Stockport	2 (66.7)	1 (33.3)	291775			City	15	5.1	Low	145	49.7	High	437	149.8	High	280	96.0	High
Royal Stoke University Hospital	UK	Stoke-on-Trent	10 (21.7)	36 (78.3)	256375			City	3	1.2	Low	68	26.5	High	183	71.4	High	235	91.7	High
Good Hope Hospital	UK	Birmingham (Sutton Coldfield)	1 (50.0)	1 (50.0)	1141820			City	55	4.8	Low	1009	88.4	High	1090	95.5	High	758	66.4	High
Musgrove Park Hospital	UK	Taunton	5 (33.3)	10 (66.7)	118979			City	10.5	8.8	Low	10.5	8.8	Low	73	61.4	High	107	89.9	High
South Warwickshire NHS Foundation Trust	UK	Warwick	3 (37.5)	5 (62.5)	138600			City	2	1.4	Low	59	42.6	High	112	80.8	High	73	52.7	High
Hampshire Hospitals NHS Trust	UK	Winchester & Basingstoke	18 (69.2)	8 (30.8)		1376316		Region	83	6.0	Low	696	50.6	High	1214	88.2	High	850	61.8	High
Wirral University Teaching Hospital	UK	Wirral	37 (94.9)	2 (5.1)	324011			City	10	3.1	Low	129	39.8	High	595	183.6	High	293	90.4	High

Royal Wolverhampton NHS Trust	UK	Wolverhampton	20 (55.6)	16 (44.4)	263357			City	40	15.2	Low	221	83.9	High	270	102.5	High	324	123.0	High
Worcestershire Royal Hospital	UK	Worcester	1 (100.0)		101328			City	3	3.0	Low	35	34.5	High	90	88.8	High	66	65.1	High
Ysbyty Gwynedd	UK	Bangor, North Wales		15 (100.0)		678500		Region	6	0.9	Low	132	19.5	Low	589	86.8	High	663	97.7	High
Barnsley Hospital NHS Foundation Trust	UK	Barnsley		4 (100.0)	246866			City	7	2.8	Low	172	69.7	High	273	110.6	High	232	94.0	High
Furness General Hospital	UK	Barrow in Furness		6 (100.0)	67049			City	6	8.9	Low	144	214.8	High	304	453.4	High	80	119.3	High
Royal Victoria Hospital	Northen Ireland	Belfast		11 (100.0)			1893667	Country	44	2.3	Low	541	28.6	High	1502	79.3	High	1448	76.5	High
Royal Bournemouth Hospital	UK	Bournemouth		37 (100.0)	183491			City	10	5.4	Low	67	36.5	High	218	118.8	High	127	69.2	High
Bradford Royal Infirmary	UK	Bradford		19 (100.0)	539776			City	7	1.3	Low	142	26.3	High	372	68.9	High	407	75.4	High
Bristol Royal Infirmary	UK	Bristol		19 (100.0)	463400			City	11	2.4	Low	140	30.2	High	268	57.8	High	199	42.9	High
Southmead Hospital	UK	Bristol		30 (100.0)	463400			City	11	2.4	Low	140	30.2	High	268	57.8	High	199	42.9	High
University Hospitals Bristol NHS Foundation Trust	UK	Bristol		14 (100.0)	463400			City	11	2.4	Low	140	30.2	High	268	57.8	High	199	42.9	High
West Suffolk Hospital	UK	Bury St Edmunds		6 (100.0)	179045			City	2	1.1	Low	27	15.1	Low	53	29.6	High	82	45.8	High
Cumberland Infirmary	UK	Carlisle		9 (100.0)	108678			City	12	11.0	Low	83	76.4	High	176	161.9	High	129	118.7	High
Broomfield Hospital	UK	Chelmsford		5 (100.0)	178388			City	14	7.8	Low	81	45.4	High	115	64.5	High	125	70.1	High
Cheltenham General Hospital	UK	Cheltenham		20 (100.0)	116306			City	3	2.6	Low	61	52.4	High	162	139.3	High	74	63.6	High
Countess of Chester Hospital	UK	Chester		4 (100.0)	343071			City	8	2.3	Low	120	35.0	High	396	115.4	High	313	91.2	High
Causeway Hospital	Northen Ireland	Coleraine		12 (100.0)			1893667	Country	44	2.3	Low	541	28.6	High	1502	79.3	High	1448	76.5	High
Dumfries and Galloway Royal Infirmary	UK	Dumfries		27 (100.0)		148860		Region	46	30.9	High	46	30.9	High	115	77.3	High	39	26.2	High
Ninewells Hospital	UK	Dundee		7 (100.0)		417470		Region	15	3.6	Low	199	47.7	High	684	163.8	High	451	108.0	High
Royal Infirmary of Edinburgh	UK	Edinburgh		10 (100.0)		907580		Region	28	3.1	Low	241	26.6	High	771	85.0	High	940	103.6	High
Western General Hospital	UK	Edinburgh		23 (100.0)		907580		Region	28	3.1	Low	241	26.6	High	771	85.0	High	940	103.6	High
Royal Bolton Hospital	UK	Farnworth		10 (100.0)	287550			City	9	3.1	Low	93	32.3	High	438	152.3	High	284	98.8	High
Medway hospital	UK	Gillingham		22 (100.0)	278556			Region	13	4.7	Low	123	44.2	High	318	114.2	High	188	67.5	High
Queen Elizabeth University Hospital	UK	Glasgow		27 (100.0)		1183120		Region	39	3.3	Low	508	42.9	High	1114	94.2	High	1098	92.8	High
Gloucestershire Royal Hospital	UK	Gloucester		3 (100.0)	129128			City	2	1.5	Low	49	37.9	High	145	112.3	High	150	116.2	High
Diana Princess of Wales Hospital Grimsby	UK	Grimsby		10 (100.0)	159563			City	15.5	9.7	Low	15.5	9.7	Low	60	37.6	High	45	28.2	High
James Paget Univeristy NHS Foundation Trust Hospital	UK	Great Yarmouth		6 (100.0)	99336			City	1	1.0	Low	39	39.3	High	110	110.7	High	50	50.3	High

Harrogate District Hospital	UK	Harrogate		17 (100.0)	160831			City	2	1.2	Low	42	26.1	High	89	55.3	High	99	61.6	High
East Sussex Healthcare (Conquest hospital and Eastbourne District General Hospital)	UK	Hastings		12 (100.0)	92855			City	1	1.1	Low	13	14.0	Low	18	19.4	Low	9	9.7	Low
Princess Royal Hospital	UK	Hayward's Heath		5 (100.0)	151022			City	6	4.0	Low	61	40.4	High	123	81.4	High	75	49.7	High
Victoria Hospital Kirkcaldy	UK	Kirkcaldy		9 (100.0)		373550		Region	7	1.9	Low	69	18.5	Low	348	93.2	High	313	83.8	High
Forth Valley Royal Hospital	UK	Larbert		8 (100.0)		306640		Region	10	3.3	Low	121	39.5	High	249	81.2	High	344	112.2	High
Lincoln County Hospital	UK	Lincoln		14 (100.0)	97541			City	1	1.0	Low	25	25.6	High	45	46.1	High	33	33.8	High
Royal Liverpool University Hospital	UK	Liverpool		22 (100.0)	498042			City	16	3.2	Low	331	66.5	High	730	146.6	High	373	74.9	High
Homerton University Hospital	UK	London (Hackney)		15 (100.0)	281120			City	30	10.7	Low	222	79.0	High	290	103.2	High	71	25.3	High
The Whittington Hospital	Northen Ireland	Londonderry		8 (100.0)			1893667	Country	44	2.3	Low	541	28.6	High	1502	79.3	High	1448	76.5	High
Luton and Dunstable Hospital	UK	Luton		12 (100.0)	213052			City	3	1.4	Low	148	69.5	High	315	147.9	High	175	82.1	High
Tunbridge Wells Hospital	UK	Maidstone		1 (100.0)	171826				3	1.7	Low	57	33.2	High	145	84.4	High	142	82.6	High
The University Hospital of South Manchester	UK	Manchester		10 (100.0)	552858			City	18	3.3	Low	210	38.0	High	654	118.3	High	311	56.3	High
Manchester Royal Infirmary	UK	Manchester		11 (100.0)	552858			City	18	3.3	Low	210	38.0	High	654	118.3	High	311	56.3	High
James Cook University Hospital	UK	Middlesbrough		19 (100.0)	138400			City	1	0.7	Low	86	62.1	High	264	190.8	High	213	153.9	High
Milton Keynes University Hospital	UK	Milton Keynes		1 (100.0)	229941			City	5	2.2	Low	143	62.2	High	211	91.8	High	118	51.3	High
Norfolk and Norwich University Hospital	UK	Norwich		4 (100.0)	143135			City	3	2.1	Low	14	9.8	Low	74	51.7	High	77	53.8	High
George Eliot Hospital	UK	Nuneaton		3 (100.0)	129883			City	14	10.8	Low	80	61.6	High	139	107.0	High	84	64.7	High
Derriford Hospital	UK	Plymouth		29 (100.0)	262100			City	6	2.3	Low	52	19.8	Low	131	50.0	High	102	38.9	High
Queen Alexandra Hospital	UK	Portsmouth		1 (100.0)	238800			City	9	3.8	Low	76	31.8	High	132	55.3	High	69	28.9	High
East Surrey Hospital	UK	Redhill		27 (100.0)	148748			City	9	6.1	Low	125	84.0	High	223	149.9	High	117	78.7	High
Glan Clwyd Hospital	UK	Rhyl		6 (100.0)		694000		Region	6	0.9	Low	132	19.0	Low	589	84.9	High	663	95.5	High
Northern General Hospital	UK	Sheffield		37 (100.0)	584853			City	36	6.2	Low	730	124.8	High	821	140.4	High	631	107.9	High
Southampton General Hospital	UK	Southampton		7 (100.0)	269781			City	6	2.2	Low	119	44.1	High	186	68.9	High	172	63.8	High
Sunderland Royal Hospital	UK	Sunderland		18 (100.0)	277417			City	3	1.1	Low	161	58.0	High	657	236.8	High	367	132.3	High
King's Mill Hospital	UK	Sutton-In-Ashfield		7 (100.0)	127918			City	6	4.7	Low	38	29.7	High	94	73.5	High	62	48.5	High
Morriston Hospital Swansea	UK	Swansea		12 (100.0)		389372		Region	29	7.4	Low	225	57.8	High	805	206.7	High	549	141.0	High
Torbay and South Devon NHS Trust	UK	Torquay		11 (100.0)	130959			City	7	5.3	Low	42	32.1	High	61	46.6	High	93	71.0	High
Pinderfields Hospital	UK	wakefield		4 (100.0)	348312			City	9	2.6	Low	105	30.1	High	268	76.9	High	162	46.5	High

Weston General Hospital	UK	Weston-super-Mare		5 (100.0)	215052			City	16	7.4	Low	39	18.1	Low	90	41.9	High	105	48.8	High
York Teaching Hospitals NHS Trust	UK	York		6 (100.0)	210618			City	7	3.3	Low	32	15.2	Low	121	57.4	High	150	71.2	High
Memorial Sloan Kettering Cancer Center	United States	New York	74 (100.0)		8175133			City	463	5.7	Low	46976	574.6	High	75707	926.1	High	46544	569.3	High
Fox Chase Cancer Center	United States	Philadelphia	4 (100.0)		1584064			City	8	0.5	Low	1307	82.5	High	6126	386.7	High	7027	443.6	High
UCSF Mission Bay	United States	San Francisco	58 (73.4)	21 (26.6)	881549			City	34	3.9	Low	411	46.6	High	649	73.6	High	554	62.8	High
UCSF Parnassus Campus	United States	San Francisco	2 (22.2)	7 (77.8)	881550			City	34	3.9	Low	411	46.6	High	649	73.6	High	554	62.8	High
Moffitt Cancer Center	United States	Tampa	4 (100.0)		1471968			City	6	0.4	Low	299	20.3	Low	565	38.4	High	254	17.3	Low
Dell Seton Medical Center	United States	Austin		21 (100.0)	1273954			City	6	0.5	Low	200	15.7	Low	771	60.5	High	677	53.1	High
Johns Hopkins Hospital	United States	Baltimore, MD		170 (100.0)	827370			City	1	0.1	Low	186	22.5	Low	875	105.8	High	1014	122.6	High
University of Colorado Hospital/Memorial Hospital/Medical Center of the Rockies (all within UCHealth System)	United States	Denver/Colorado Springs/Loveland		7 (100.0)		5758736		Region	131	2.3	Low	2835	49.2	High	5314	92.3	High	7004	121.6	High
Henry Ford Hospital	United States	Detroit, Michigan		2 (100.0)	1749343			City	13	0.7	Low	3722	212.8	High	8809	503.6	High	4185	239.2	High
Duke University Medical Center	United States	Durham, NC ?		8 (100.0)	321488			City	1	0.3	Low	121	37.6	High	208	64.7	High	398	123.8	High
University of Texas MD Anderson Cancer Center	United States	Houston		69 (100.0)	4713325			City	13	0.3	Low	550	11.7	Low	3534	75.0	High	2259	47.9	High
Dartmouth-Hitchcock Medical Center	United States	Lebanon, NH		4 (100.0)	89118			City	5	5.6	Low	30	33.7	High	9	10.1	Low	6	6.7	Low
Kaiser Permanente West Los Angeles	United States	Los Angeles		6 (100.0)	9818605			City	53	0.5	Low	2958	30.1	High	7485	76.2	High	12686	129.2	High
University of Wisconsin	United States	Madison		24 (100.0)	488075			City	5	1.0	Low	189	38.7	High	157	32.2	High	77	15.8	Low
Vanderbilt University Medical Center	United States	Nashville		15 (100.0)	694144			City	17	2.4	Low	524	75.5	High	951	137.0	High	1177	169.6	High
Kaiser Permanente Panorama City Medical Center	United States	Los Angeles (Panorama City)		6 (100.0)	9818605			City	53	0.5	Low	2958	30.1	High	7485	76.2	High	12686	129.2	High
Kaiser Permanente San Diego Medical Center	United States	San Diego		20 (100.0)	3095313			City	39	1.3	Low	694	22.4	Low	1278	41.3	High	1615	52.2	High
Harborview Medical Center	United States	Seattle		1 (100.0)	1931249			City	421	21.8	Low	1911	99.0	High	2367	122.6	High	1611	83.4	High
UCSF Medical Center	United States	San Fransisco		10 (100.0)	881550			City	34	3.9	Low	411	46.6	High	649	73.6	High	554	62.8	High
SUNY Upstate University Hospital	United States	Syracuse		6 (100.0)	467026			City	1	0.2	Low	193	41.3	High	255	54.6	High	383	82.0	High
Hospital Pereira	Uruguay	Montevideo		4 (100.0)			3449285	Country	8	0.2	Low	330	9.6	Low	155	4.5	Low	150	4.3	Low
Health Sciences Centre	Canada	Winnipeg		1 (100.0)		1278365		Region	7	0.5	Low	96	7.5	Low	144	11.3	Low	29	2.3	Low

The Walton Centre NHS Foundation Trust	UK	Liverpool		2 (100.0)	498042			City	16	3.2	Low	331	66.5	High	730	146.6	High	373	74.9	High
The National Hospital for Neurology and Neurosurgery	UK	London		7 (100.0)	270029			City	32	11.9	Low	211	78.1	High	246	91.1	High	95	35.2	High
Whipps Cross University Hospital	UK	London		1 (100.0)	276983			City	15	5.4	Low	277	100.0	High	328	118.4	High	105	37.9	High
Salford Royal Hospital	UK	Salford		4 (100.0)	248419			City	9	3.6	Low	182	73.3	High	334	134.5	High	270	108.7	High
Tripoli Central Hospital	Libya	Tripoli		1 (100.0)			6871288	Country	4	0.1	Low	4	0.1	Low	27	0.4	Low	26	0.4	Low
Cheikh Zaid International University Hospital	Morocco	Rabat	3 (100.0)				36472000	Country	28	0.1	Low	589	1.6	Low	1407	3.9	Low	2399	6.6	Low
Centre Hospitalier Universitaire Ibn Sina Rabat	Morocco	Rabat		5 (100.0)			36472000	Country	28	0.1	Low	589	1.6	Low	1407	3.9	Low	2399	6.6	Low
Clinic for Neurosurgery, Clinical Center of Serbia	Serbia	Belgrade	9 (100.0)				6963764	Country	48	0.7	Low	852	12.2	Low	3973	57.1	High	4136	59.4	High
Sahlgrenska University Hospital	Sweden	Gothenburg	1 (100.0)			1725881		Region	170	9.9	Low	250	14.5	Low	1059	61.4	High	1277	74.0	High
University of Texas Southwestern	United States	Dallas		1 (100.0)	2635516			City	14	0.5	Low	617	23.4	Low	1355	51.4	High	1545	58.6	High

High risk was defined as a 14-day cumulative notification rate greater than 25 per 100,000 population and low risk less than 25 cases per 100,000 population according to European Centre for Disease Control and Prevention reporting criteria during two-week periods in March and April 2020. The participating hospital listed is that in where the initial multidisciplinary, tumour board or surgeon decision for curative surgery was made.

Supplementary table 2. Primary operations performed in COVID-19 free surgical pathways and hospitals with no defined pathway.

Primary operation(s) and OPCS-4 Code	COVID-19 free surgical pathway	No defined pathway
A021 Excision Of Lesion Of Tissue Of Frontal Lobe Of Brain	23 (23.7)	74 (76.3)
A022 Excision Of Lesion Of Tissue Of Temporal Lobe Of Brain	12 (22.6)	41 (77.4)
A023 Excision Of Lesion Of Tissue Of Parietal Lobe Of Brain	8 (18.2)	36 (81.8)
A024 Excision Of Lesion Of Tissue Of Occipital Lobe Of Brain	6 (40.0)	9 (60.0)
A025 Excision Of Lesion Of Tissue Of Cerebellum	2 (11.1)	16 (88.9)
A026 Excision Of Lesion Of Tissue Of Brain Stem	2 (33.3)	4 (66.7)
A032 Stereotactic Ablation Of Tissue Of Thalamus		1 (100.0)
A034 Stereotactic Ablation Of Tissue Of Brain Stem		1 (100.0)
A041 Open Biopsy Of Lesion Of Tissue Of Frontal Lobe Of Brain		3 (100.0)
A042 Open Biopsy Of Lesion Of Tissue Of Temporal Lobe Of Brain		1 (100.0)
A043 Open Biopsy Of Lesion Of Tissue Of Parietal Lobe Of Brain		1 (100.0)
A044 Open Biopsy Of Lesion Of Tissue Of Occipital Lobe Of Brain		1 (100.0)
A045 Open Biopsy Of Lesion Of Tissue Of Cerebellum		1 (100.0)
A081 Biopsy Of Lesion Of Tissue Of Frontal Lobe Of Brain	3 (30.0)	7 (70.0)
A082 Biopsy Of Lesion Of Tissue Of Temporal Lobe Of Brain		1 (100.0)
A083 Biopsy Of Lesion Of Tissue Of Parietal Lobe Of Brain		4 (100.0)
A086 Biopsy Of Lesion Of Tissue Of Brain Stem		3 (100.0)
A107 Stereotactic Radiosurgery On Tissue Of Brain	2 (66.7)	1 (33.3)
A124 Creation Of Ventriculoperitoneal Shunt	1 (50.0)	1 (50.0)
A171 Endoscopic Extirpation Of Lesion Of Ventricle Of Brain	1 (20.0)	4 (80.0)
A295 Excision Of Lesion Of Acoustic Nerve (Viii)	1 (14.3)	6 (85.7)
A298 Excision Of Lesion Of Specified Cranial Nerve		5 (100.0)
A381 Extirpation Of Lesion Of Meninges Of Cortex Of Brain	2 (10.5)	17 (89.5)
A382 Extirpation Of Lesion Of Meninges Of Sphenoidal Ridge Of Cranium	2 (20.0)	8 (80.0)
A383 Extirpation Of Lesion Of Meninges Of Subfrontal Region Of Brain		12 (100.0)
A384 Extirpation Of Lesion Of Meninges Of Parasagittal Region		7 (100.0)
A386 Extirpation Of Lesion Of Tentorium Cerebelli		1 (100.0)
A422 Biopsy Of Lesion Of Meninges Of Brain	1 (33.3)	2 (66.7)
A481 Biopsy Of Lesion Of Spinal Cord		1 (100.0)
A511 Extirpation Of Lesion Of Meninges Of Spinal Cord		2 (100.0)
A604 Radiofrequency Controlled Thermal Destruction Of Peripheral		1 (100.0)
A611 Excision Of Lesion Of Peripheral Nerve		1 (100.0)
A764 Chemical Destruction Of Perivascular Sympathetic Nerve		1 (100.0)
B012 Trans-Sphenoidal Hypophysectomy	1 (50.0)	1 (50.0)
B014 Transcranial Hypophysectomy		1 (100.0)
B041 Excision Of Lesion Of Pituitary Gland	4 (9.3)	39 (90.7)
B042 Biopsy Of Lesion Of Pituitary Gland		1 (100.0)
B043 Decompression Of Pituitary Gland		1 (100.0)
B045 Operations On Pituitary Stalk	2 (66.7)	1 (33.3)
B081 Total Thyroidectomy	82 (31.5)	178 (68.5)
B082 Subtotal Thyroidectomy		3 (100.0)
B083 Hemithyroidectomy	28 (48.3)	30 (51.7)
B084 Lobectomy Of Thyroid Gland	9 (64.3)	5 (35.7)
B085 Isthmectomy Of Thyroid Gland	4 (66.7)	2 (33.3)
B086 Partial Thyroidectomy		1 (100.0)
B121 Excision Of Lesion Of Thyroid Gland		1 (100.0)
B122 Biopsy Of Lesion Of Thyroid Gland	4 (100.0)	
B142 Global Parathyroidectomy		1 (100.0)
B162 Biopsy Of Lesion Of Parathyroid Gland		1 (100.0)
B181 Trans-Sternal Thymectomy	3 (17.6)	14 (82.4)
B182 Transcervical Thymectomy	1 (50.0)	1 (50.0)
B202 Exploration Of Thymus Gland		2 (100.0)
B221 Bilateral Salpingoophorectomy	2 (66.7)	1 (33.3)
B222 Bilateral Adrenalectomy		1 (100.0)
B223 Unilateral Adrenalectomy	1 (16.7)	5 (83.3)
B224 Partial Adrenalectomy		1 (100.0)
B271 Total Mastectomy and Excision of both Pectoral Muscles	21 (80.8)	5 (19.2)
B272 Total Mastectomy And Excision Of Both Pectoral Muscles	3 (16.7)	15 (83.3)
B273 Total Mastectomy And Excision Of Pectoralis Minor Muscle	49 (90.7)	5 (9.3)
B274 Total Mastectomy	768 (42.9)	1024 (57.1)
B275 Subcutaneous Mastectomy	77 (46.4)	89 (53.6)
B276 Skin Sparing Mastectomy	46 (28.8)	114 (71.2)
B282 Partial Excision of Breast	358 (34.8)	671 (65.2)
B283 Excision of lesion of breast	378 (33.1)	763 (66.9)
B284 Re-excision of breast margins	5 (23.8)	16 (76.2)
B287 Wire guided excision of lesion of breast	1 (25.0)	3 (75.0)
B289 Unspecified other excision of breast	1 (50.0)	1 (50.0)
B292 Reconstruction Of Breast Using Local Flap Of Skin	4 (57.1)	3 (42.9)
B294 Reconstruction Of Breast Using Distant Flap Of Skin		1 (100.0)
B296 Reconstruction Of Breast Using Glandular Remodelling	2 (66.7)	1 (33.3)
B297 Reconstruction Of Breast Using Dermoglandular Flap	7 (87.5)	1 (12.5)
B301 Insertion Of Prosthesis For Breast	2 (100.0)	
B311 Reduction mammoplasty	4 (23.5)	13 (76.5)
B312 Augmentation mammoplasty	2 (100.0)	
B314 Revision of mammoplasty	2 (12.5)	14 (87.5)
B321 Percutaneous Biopsy Of Lesion Of Breast		1 (100.0)
B322 Biopsy Of Lesion Of Breast	24 (75.0)	8 (25.0)
B323 Wire Guided Biopsy Of Lesion Of Breast	31 (27.9)	80 (72.1)
B344 Microdochotomy		1 (100.0)

B376 Partial Capsulectomy Of Breast	1 (100.0)	
B393 Reconstruction Of Breast Using Free Deep Inferior Epigastric Flap		1 (100.0)
B411 Radionuclide Guided Excision Of Lesion Of Breast		56 (100.0)
B412 Radionuclide Guided Partial Excision Of Breast	4 (16.7)	20 (83.3)
C011 Exenteration Of Orbit	1 (16.7)	5 (83.3)
C061 Biopsy Of Lesion Of Orbit		1 (100.0)
C121 Excision Of Lesion Of Eyelid	5 (83.3)	1 (16.7)
C391 Excision Of Lesion Of Conjunctiva	1 (100.0)	
D012 Partial Excision Of External Ear		3 (100.0)
D021 Excision Of Lesion Of External Ear	8 (50.0)	8 (50.0)
D101 Radical Mastoidectomy		5 (100.0)
D104 Simple Mastoidectomy	1 (14.3)	6 (85.7)
D105 Excision Of Lesion Of Mastoid	1 (50.0)	1 (50.0)
E011 Total Excision Of Nose	4 (66.7)	2 (33.3)
E018 Other specified excision of nose		2 (100.0)
E101 Biopsy Of Lesion Of Nose	2 (40.0)	3 (60.0)
E132 Excision Of Lesion Of Maxillary Antrum	5 (11.4)	39 (88.6)
E134 Biopsy Of Lesion Of Maxillary Antrum		1 (100.0)
E143 External ethmoidectomy		1 (100.0)
E172 Excision of lesion of nasal sinus	1 (100.0)	
E191 Total Pharyngectomy		8 (100.0)
E192 Partial Pharyngectomy	2 (22.2)	7 (77.8)
E198 Other specified excision of pharynx		1 (100.0)
E199 Unspecified excision of pharynx		1 (100.0)
E242 Endoscopic Extirpation Of Lesion Of Pharynx		2 (100.0)
E251 Diagnostic Endoscopic Examination Of Nasopharynx And Biopsy	1 (100.0)	
E252 Diagnostic Endoscopic Examination Of Pharynx And Biopsy Of		4 (100.0)
E291 Total Laryngectomy	12 (21.8)	43 (78.2)
E292 Partial Horizontal Laryngectomy	1 (50.0)	1 (50.0)
E293 Partial Vertical Laryngectomy		1 (100.0)
E294 Partial Laryngectomy	1 (14.3)	6 (85.7)
E295 Laryngofissure And Cordectomy Of Vocal Cord	14 (60.9)	9 (39.1)
E296 Laryngectomy	4 (28.6)	10 (71.4)
E302 Excision Of Lesion Of Larynx Using Lateral Pharyngotomy		1 (100.0)
E303 Open Destruction Of Lesion Of Larynx	1 (25.0)	3 (75.0)
E361 Diagnostic endoscopic Examination Of Larynx And Biopsy Of Lesion	1 (5.9)	16 (94.1)
E391 Open Excision Of Lesion Of Trachea		1 (100.0)
E411 Open Insertion Of Tubal Prosthesis In Trachea		1 (100.0)
E421 Permanent tracheostomy		1 (100.0)
E424 Revision Of Tracheostomy		2 (100.0)
E461 Sleeve Resection Of Bronchus And Anastomosis		5 (100.0)
E463 Excision Of Lesion Of Bronchus	1 (50.0)	1 (50.0)
E502 Endoscopic Laser Destruction Of Lesion Of Lower Respiratory		2 (100.0)
E504 Endoscopic Aspiration Of Lower Respiratory Tract Using Rigid		1 (100.0)
E541 Total Pneumonectomy	5 (29.4)	12 (70.6)
E542 Bilobectomy Of Lung	155 (30.0)	399 (72.0)
E544 Excision Of Segment Of Lung	47 (33.1)	95 (66.9)
E545 Partial Lobectomy Of Lung	7 (10.6)	59 (89.4)
E552 Open Excision Of Lesion Of Lung	3 (50.0)	3 (50.0)
E554 Open Destruction Of Lesion Of Lung		1 (100.0)
E593 Biopsy Of Lesion Of Lung	2 (33.3)	4 (66.7)
E621 Endoscopic Extirpation Of Lesion Of Mediastinum		2 (100.0)
E629 Unspecified therapeutic endoscopic operations on mediastinum		1 (100.0)
E631 Diagnostic endoscopic examination of mediastinum and biopsy		1 (100.0)
E641 Endoscopic Extirpation Of Lesion Of Nasal Cavity	1 (20.0)	4 (80.0)
F011 Excision Of Vermilion Border Of Lip And Advancement Of Mucosa	1 (20.0)	4 (80.0)
F021 Excision Of Lesion Of Lip	5 (16.1)	26 (83.9)
F062 Biopsy Of Lesion Of Lip		1 (100.0)
F221 Total Glossectomy	2 (16.7)	10 (83.3)
F222 Partial Glossectomy	36 (24.8)	109 (75.2)
F231 Excision Of Lesion Of Tongue	19 (15.0)	108 (85.0)
F241 Biopsy Of Lesion Of Tongue		5 (100.0)
F281 Excision Of Lesion Of Palate	1 (5.3)	18 (94.7)
F324 Operations On Uvula		1 (100.0)
F325 Uvulopalatopharyngoplasty		1 (100.0)
F328 Other specified other operations on palate		2 (100.0)
F341 Bilateral Dissection Tonsillectomy		10 (100.0)
F343 Bilateral Laser Tonsillectomy		2 (100.0)
F344 Bilateral Excision Of Tonsil	1 (50.0)	1 (50.0)
F348 Other specified excision of tonsil		3 (100.0)
F362 Biopsy Of Lesion Of Tonsil		2 (100.0)
F366 Excision Of Lesion Of Tonsil	4 (17.4)	19 (82.6)
F381 Excision of lesion of floor of mouth		13 (100.0)
F421 Biopsy Of Lesion Of Mouth	2 (25.0)	6 (75.0)
F423 Removal Of Excess Mucosa From Mouth		2 (100.0)
F441 Total Excision Of Parotid Gland	8 (17.8)	37 (82.2)
F442 Partial Excision Of Parotid Gland	7 (20.0)	28 (80.0)
F443 Excision Of Parotid Gland	2 (25.0)	6 (75.0)
F444 Excision Of Submandibular Gland	2 (40.0)	3 (60.0)
F445 Excision Of Sublingual Gland		3 (100.0)
F451 Excision Of Lesion Of Parotid Gland	1 (20.0)	4 (80.0)
F452 Excision Of Lesion Of Submandibular Gland	2 (100.0)	
F454 Excision Of Lesion Of Salivary Gland	1 (25.0)	3 (75.0)
G011 Oesophagogastrectomy and Anastomosis of Oesophagus to Stomach	12 (14.8)	69 (85.2)
G012 Oesophagogastrectomy And Anastomosis Of Oesophagus To Transposed Jejunum		2 (100.0)
G013 Oesophagogastrectomy And Anastomosis Of Oesophagus To Jejunum	2 (16.7)	10 (83.3)
G021 Total Oesophagectomy And Anastomosis Of Pharynx To Stomach	14 (9.3)	137 (90.7)

G022 Total Oesophagectomy/Interposition Of Microvascularly Attached Jejunum	1 (100.0)	
G025 Total Oesophagectomy And Interposition Of Colon		1 (100.0)
G031 Partial Oesophagectomy And End To End Anastomosis Of Oesophagus	2 (9.5)	21 (90.5)
G033 Partial Oesophagectomy And Anastomosis Of Oesophagus To Transposed Jejunum	1 (10.0)	9 (90.0)
G034 Partial Oesophagectomy And Anastomosis Of Oesophagus To Jejunum	1 (10.0)	9 (90.0)
G041 Excision Of Lesion Of Oesophagus		1 (100.0)
G052 Bypass Of Oesophagus By Anastomosis Of Oesophagus To Stomach	1 (11.1)	8 (88.9)
G271 Total Gastrectomy And Excision Of Surrounding Tissue	4 (100.0)	
G272 Total Gastrectomy And Anastomosis Of Oesophagus To Duodenum	2 (18.2)	9 (81.8)
G273 Total gastrectomy and interposition of jejunum	25 (20.8)	95 (79.2)
G274 Total Gastrectomy And Anastomosis Of Oesophagus To Transposed Jejunum	3 (33.3)	6 (66.7)
G275 Total Gastrectomy And Anastomosis Of Oesophagus To Jejunum	41 (28.3)	104 (71.7)
G281 Partial gastrectomy and anastomosis of stomach to duodenum	45 (30.8)	101 (69.2)
G281 Partial Gastrectomy And Anastomosis Of Stomach To Duodenum	7 (21.2)	1 (78.8)
G282 Partial Gastrectomy And Anastomosis Of Stomach To Transposed Jejunum	9 (39.1)	14 (60.9)
G283 Partial Gastrectomy And Anastomosis Of Stomach To Jejunum	51 (30.4)	117 (69.6)
G285 Sleeve Gastrectomy	3 (14.3)	18 (85.7)
G288 Other specified partial excision of stomach		4 (100.0)
G292 Open Excision Of Lesion Of Stomach	1 (12.5)	7 (87.5)
G321 Bypass Of Stomach By Anastomosis Of Stomach To Transposed Je		2 (100.0)
G336 Attention To Connection Of Stomach To Jejunum	1 (100.0)	
G341 Creation Of Permanent Gastrostomy	1 (25.0)	3 (75.0)
G342 Creation Of Temporary Gastrostomy		2 (100.0)
G431 Fibreoptic Endoscopic Snare Resection/Lesion Of Upper Gastrointestinal Tract	1 (100.0)	
G454 Fibreoptic Endoscopic Examination Of Upper Gastrointestinal Tract And Biopsy		1 (100.0)
G491 Gastroduodenectomy		2 (100.0)
G493 Partial Excision Of Duodenum	1 (16.7)	5 (83.3)
G501 Excision Of Lesion Of Duodenum		2 (100.0)
G511 Bypass Of Duodenum By Anastomosis Of Stomach To Jejunum	1 (8.3)	11 (91.7)
G512 Bypass Of Duodenum By Anastomosis Of Duodenum To Duodenum		1 (100.0)
G543 Endoscopic Insertion Of Tubal Prosthesis Into Duodenum		1 (100.0)
G582 Total Jejunectomy And Anastomosis Of Duodenum To Ileum		1 (100.0)
G584 Partial Jejunectomy And Anastomosis Of Jejunum To Ileum	1 (16.7)	5 (83.3)
G601 Creation Of Jejunostomy	1 (100.0)	
G612 Bypass Of Jejunum By Anastomosis Of Jejunum To Ileum	1 (100.0)	
G692 Ileectomy And Anastomosis Of Duodenum To Ileum	1 (100.0)	
G693 Ileectomy And Anastomosis Of Ileum To Ileum	1 (10.0)	9 (90.0)
G694 Ileectomy And Anastomosis Of Ileum To Colon		1 (100.0)
G702 Excision Of Lesion Of Ileum	4 (80.0)	1 (20.0)
G712 Bypass Of Ileum By Anastomosis Of Ileum To Ileum	2 (100.0)	
G721 Anastomosis Of Ileum To Caecum	2 (66.7)	1 (33.3)
G722 Anastomosis Of Ileum To Transverse Colon		1 (100.0)
G723 Anastomosis Of Ileum To Colon	3 (60.0)	2 (40.0)
G724 Anastomosis Of Ileum To Rectum	1 (50.0)	1 (50.0)
G734 Resection Of Ileocolic Anastomosis	1 (25.0)	3 (75.0)
G742 Creation Of Temporary Ileostomy	1 (10.0)	9 (90.0)
G743 Creation Of Defunctioning Ileostomy	3 (12.0)	22 (88.0)
G753 Closure Of Ileostomy	1 (25.0)	3 (75.0)
H028 Other specified other excision of appendix	1 (100.0)	
H041 Panproctocolectomy And Ileostomy	3 (17.6)	14 (82.4)
H042 Panproctocolectomy And Anastomosis Of Ileum To Anus And Creation of Pouch	1 (33.3)	2 (66.7)
H051 Total Colectomy And Anastomosis Of Ileum To Rectum	7 (28.0)	18 (72.0)
H052 Total Colectomy And Ileostomy And Creation Of Rectal Fistula		3 (100.0)
H053 Total Colectomy And Ileostomy		18 (100.0)
H061 Extended Right Hemicolectomy And End To End Anastomosis	5 (21.7)	18 (78.3)
H062 Extended Right Hemicolectomy And Anastomosis Of Ileum To Colon	58 (22.6)	199 (77.4)
H063 Extended Right Hemicolectomy And Anastomosis	13 (13.8)	81 (86.2)
H064 Extended Right Hemicolectomy And Ileostomy		17 (100.0)
H065 Extended Right Hemicolectomy And End To Side Anastomosis	6 (26.1)	17 (73.9)
H073 Right hemicolectomy and Anastomosis	113 (15.5)	616 (84.5)
H074 Right hemicolectomy and ileostomy	3 (6.1)	46 (93.9)
H081 Transverse Colectomy And End To End Anastomosis	4 (33.3)	8 (66.7)
H082 Transverse Colectomy And Anastomosis Of Ileum To Colon	1 (20.0)	4 (80.0)
H083 Transverse Colectomy And Anastomosis	3 (37.5)	5 (62.5)
H084 Transverse Colectomy And Ileostomy		1 (100.0)
H085 Transverse Colectomy And Exteriorisation Of Bowel	2 (40.0)	3 (60.0)
H086 Transverse Colectomy And End To Side Anastomosis	2 (50.0)	2 (50.0)
H091 Left Hemicolectomy And End To End Anastomosis Of Colon To Rectum	13 (11.1)	104 (88.9)
H092 Left Hemicolectomy And End To End Anastomosis Of Colon To Colon	24 (25.0)	72 (75.0)
H093 Left Hemicolectomy And Anastomosis	25 (40.0)	38 (60.3)
H094 Left Hemicolectomy And Ileostomy		12 (100.0)
H095 Left Hemicolectomy And Exteriorisation Of Bowel	6 (14.6)	35 (85.4)
H096 Left Hemicolectomy And End To Side Anastomosis	6 (42.9)	8 (57.1)
H101 Sigmoid Colectomy And End To End Anastomosis Of Ileum To Rectum	4 (44.4)	5 (55.6)
H102 Sigmoid Colectomy And Anastomosis Of Colon To Rectum	49 (21.9)	175 (78.1)
H103 Sigmoid Colectomy And Anastomosis	4 (11.4)	31 (88.6)
H104 Sigmoid Colectomy And Ileostomy	1 (16.7)	5 (83.3)
H105 Sigmoid Colectomy And Exteriorisation Of Bowel	10 (18.5)	44 (81.5)
H106 Sigmoid Colectomy And End To Side Anastomosis	1 (12.5)	7 (87.5)
H113 Colectomy and anastomosis	1 (100.0)	
H121 Excision Of Diverticulum Of Colon		1 (100.0)
H122 Excision Of Lesion Of Colon		2 (100.0)
H131 Bypass Of Colon By Anastomosis Of Ileum To Colon		3 (100.0)
H135 Bypass Of Colon By Anastomosis Of Colon To Rectum	1 (100.0)	
H151 Loop colostomy		2 (100.0)
H152 End colostomy	1 (100.0)	
H201 Fibreoptic Endoscopic Snare Resection Of Lesion Of Colon	1 (100.0)	

H291 Subtotal Excision Of Colon And Rectum And Creation Of Coloni		1 (100.0)
H293 Subtotal Excision Of Colon And Creation Of Colonic Pouch		1 (100.0)
H295 Subtotal Excision Of Colon And Anastomosis Of Colon To Ileum	5 (20.8)	19 (79.2)
H298 Other Specified Subtotal Excision of Colon		1 (100.0)
H321 Resiting Of Colostomy	8 (42.1)	11 (57.9)
H331 Abdominoperineal Excision Of Rectum And End Colostomy	47 (19.3)	196 (80.7)
H332 Proctectomy And Anastomosis Of Colon To Anus	1 (7.1)	13 (92.9)
H333 Anterior Resection Of Rectum And Anastomosis Of Colon To Rectum	123 (19.6)	505 (80.4)
H334 Anterior Resection Of Rectum And Anastomosis	56 (23.5)	182 (76.5)
H335 Rectosigmoidectomy And Closure Of Rectal Stump And Exteriorisation of Bowel	7 (20.6)	27 (79.4)
H336 Anterior Resection Of Rectum And Exteriorisation Of Bowel	34 (17.7)	158 (82.3)
H337 Perineal Resection Of Rectum		2 (100.0)
H341 Open Excision Of Lesion Of Rectum	1 (20.0)	4 (80.0)
H401 Trans-Sphincteric Excision Of Mucosa Of Rectum		2 (100.0)
H402 Trans-Sphincteric Excision Of Lesion Of Rectum		1 (100.0)
H404 Trans-Sphincteric Anastomosis Of Colon To Anus		1 (100.0)
H411 Rectosigmoidectomy And Peranal Anastomosis	2 (9.1)	20 (90.9)
H412 Peranal Excision Of Lesion Of Rectum	6 (18.2)	27 (81.8)
H413 Peranal Destruction Of Lesion Of Rectum		1 (100.0)
H414 Peranal Mucosal Proctectomy And Endoanal Anastomosis		1 (100.0)
H415 Peranal Resection Of Rectum Using Staples		1 (100.0)
H561 Biopsy Of Lesion Of Anus	1 (100.0)	
J011 Orthotopic Transplantation Of Liver		1 (100.0)
J015 Orthotopic Transplantation Of Whole Liver	4 (40.0)	6 (60.0)
J021 Right Hemihepatectomy	10 (13.9)	62 (86.1)
J022 Left Hemihepatectomy	23 (37.1)	39 (62.9)
J023 Resection Of Segment Of Liver	44 (30.3)	101 (69.7)
J024 Wedge Excision Of Liver	27 (29.7)	64 (70.3)
J026 Extended Right Hemihepatectomy	8 (40.0)	12 (60.0)
J027 Extended Left Hemihepatectomy	3 (16.7)	15 (83.3)
J028 Other specified partial excision of liver		6 (100.0)
J031 Excision Of Lesion Of Liver	7 (15.2)	39 (84.8)
J032 Destruction Of Lesion Of Liver		1 (100.0)
J033 Thermal Ablation Of Single Lesion Of Liver	2 (33.3)	4 (66.7)
J035 Excision Of Multiple Lesions Of Liver	11 (28.9)	27 (71.1)
J053 Open Wedge Biopsy Of Lesion Of Liver		6 (100.0)
J058 Other specified incision of liver		1 (100.0)
J083 Endoscopic Microwave Ablation Lesion Liver Using Laparoscope		2 (100.0)
J092 Laparoscopic Ultrasound Examination Of Liver And Biopsy Of Lesion		1 (100.0)
J181 Total Cholecystectomy And Excision Of Surrounding Tissue		2 (100.0)
J182 Total Cholecystectomy And Exploration Of Common Bile Duct		1 (100.0)
J183 Total Cholecystectomy	2 (33.3)	4 (66.7)
J273 Partial Excision/Bile Duct And Anastomosis/Bile Duct To Jejunum		1 (100.0)
J281 Excision Of Lesion Of Bile Duct		1 (100.0)
J291 Anastomosis Of Hepatic Duct To Transposed Jejunum		5 (100.0)
J292 Anastomosis Of Hepatic Duct To Jejunum	1 (25.0)	3 (75.0)
J301 Anastomosis Of Common Bile Duct To Duodenum	1 (100.0)	
J302 Anastomosis Of Common Bile Duct To Transposed Jejunum		1 (100.0)
J303 Anastomosis Of Common Bile Duct To Jejunum	1 (25.0)	3 (75.0)
J331 Open Removal/Calculus From Bile Duct/Drainage Of Bile Duct	1 (50.0)	1 (50.0)
J551 Total Pancreatectomy And Excision Of Surrounding Tissue	2 (7.4)	25 (92.6)
J558 Other specified total excision of pancreas	1 (33.3)	2 (66.7)
J561 Pancreaticoduodenectomy And Excision Of Surrounding Tissue	32 (13.5)	205 (86.5)
J563 Pancreaticoduodenectomy	1 (16.7)	5 (83.3)
J564 Subtotal Excision Of Head Of Pancreas With Preservation Of Duodenum		3 (100.0)
J571 Subtotal Pancreatectomy	4 (19.0)	17 (81.0)
J573 Left Pancreatectomy	4 (8.9)	41 (91.1)
J575 Excision Of Tail Of Pancreas	1 (5.3)	18 (94.7)
J582 Excision Of Lesion Of Pancreas	3 (42.9)	4 (57.1)
J671 Diagnostic Percutaneous Aspiration Of Lesion Of Pancreas	1 (100.0)	
J692 Total Splenectomy	1 (16.7)	5 (83.3)
K248 Other specified other operations on ventricles of heart		1 (100.0)
L271 Endovascular insertion of stent graft for infrarenal abdominal aortic aneurysm	1 (100.0)	
L912 Insertion of central venous catheter NEC	1 (100.0)	
L973 Isolated limb perfusion	1 (100.0)	
M021 Nephrectomy And Excision Of Perirenal Tissue	11 (15.5)	60 (84.5)
M022 Nephroureterectomy	14 (31.1)	31 (68.9)
M023 Bilateral Nephrectomy		1 (100.0)
M025 Nephrectomy	23 (20.7)	88 (79.3)
M042 Open Excision Of Lesion Of Kidney		1 (100.0)
M182 Excision Of Segment Of Ureter		2 (100.0)
M183 Secondary Ureterectomy		1 (100.0)
M341 Cystoprostatectomy	9 (24.3)	28 (75.7)
M342 Cystourethrectomy	1 (33.3)	2 (66.7)
M343 Cystectomy	6 (17.1)	29 (82.9)
M344 Simple Cystectomy		2 (100.0)
M421 Endoscopic Resection Of Lesion Of Bladder	18 (28.6)	45 (71.4)
M422 Endoscopic Cauterisation Of Lesion Of Bladder		6 (100.0)
M423 Endoscopic Destruction Of Lesion Of Bladder		2 (100.0)
M451 Diagnostic Endoscopic Exam Of Bladder And Biopsy/Lesion Of Bladder	2 (100.0)	
M455 Diagnostic Endoscopic Examination Of Bladder Using Rigid Cystoscope	6 (75.0)	2 (25.0)
M611 Total Excision Of Prostate And Capsule Of Prostate	2 (3.8)	50 (96.2)
M612 Retropubic Prostatectomy	5 (5.6)	85 (94.4)
M614 Perineal Prostatectomy	3 (23.1)	10 (76.9)
M651 Endoscopic Resection Of Prostate Using Electrotome		1 (100.0)
M653 Endoscopic Resection Of Prostate		4 (100.0)
M723 Excision Of Lesion Of Urethra	1 (100.0)	

M832 Exploration Of Retropubic Space	1 (100.0)	
N011 Excision Of Scrotum	1 (100.0)	
N071 Excision Of Lesion Of Testis		1 (100.0)
N243 Excision Of Male Periurethral Tissue	1 (100.0)	
N261 Total Amputation Of Penis	2 (100.0)	
N271 Excision Of Lesion Of Penis	1 (100.0)	
P051 Total Excision Of Vulva	11 (44.0)	14 (56.0)
P052 Partial Excision Of Vulva	15 (35.7)	27 (64.3)
P054 Excision Of Lesion Of Vulva	3 (15.8)	16 (84.2)
P056 Reduction Labia Minor		1 (100.0)
P065 Excision Of Lesion Of Labia	1 (100.0)	
P091 Biopsy Of Lesion Of Vulva		1 (100.0)
P201 Excision Of Lesion Of Vagina	1 (25.0)	3 (75.0)
P317 Extirpation Of Lesion Of Pouch Of Douglas		1 (100.0)
Q011 Amputation Of Cervix Uteri	1 (20.0)	4 (80.0)
Q013 Excision Of Lesion Of Cervix Uteri	2 (28.6)	5 (71.4)
Q014 Large Loop Excision Of Transformation Zone		3 (100.0)
Q018 Other specified excision of cervix uteri	2 (50.0)	2 (50.0)
Q023 Cauterisation Of Lesion Of Cervix Uteri	1 (100.0)	
Q031 Knife Cone Biopsy Of Cervix Uteri		2 (100.0)
Q033 Cone Biopsy Of Cervix Uteri		7 (100.0)
Q071 Abdominal Hysterocolpectomy And Excision Of Periuterine Tissue	16 (43.2)	21 (56.8)
Q072 Abdominal Hysterectomy And Excision Of Periuterine Tissue	139 (31.5)	302 (68.5)
Q073 Abdominal Hysterocolpectomy	8 (18.2)	36 (81.8)
Q074 Total Abdominal Hysterectomy	110 (29.2)	267 (70.8)
Q075 Subtotal Abdominal Hysterectomy	1 (33.3)	2 (66.7)
Q081 Vaginal Hysterocolpectomy And Excision Of Periuterine Tissue		1 (100.0)
Q082 Vaginal Hysterectomy And Excision Of Periuterine Tissue	3 (37.5)	5 (62.5)
Q083 Vaginal Hysterocolpectomy		4 (100.0)
Q099 Unspecified other open operations on uterus		1 (100.0)
Q102 Curettage Of Products Of Conception From Uterus Neck		1 (100.0)
Q176 Endoscopic Microwave Ablation Of Endometrium	2 (66.7)	1 (33.3)
Q181 Diagnostic Endoscopic Examination Of Uterus And Biopsy Of Le	1 (100.0)	
Q221 Bilateral Salpingoophorectomy	37 (31.6)	80 (68.4)
Q223 Bilateral Oophorectomy		3 (100.0)
Q231 Unilateral Salpingoophorectomy	6 (30.0)	14 (70.0)
Q232 Salpingoophorectomy Of Remaining Solitary Fallopian Tube And		2 (100.0)
Q233 Unilateral Salpingectomy	1 (25.0)	3 (75.0)
Q235 Unilateral Oophorectomy		3 (100.0)
Q43. 8 Other specified partial excision of ovary	2 (66.7)	1 (33.3)
Q432 Excision Of Lesion Of Ovary	5 (38.5)	8 (61.5)
Q501 Diagnostic Endoscopic Examination Of Ovary And Biopsy Of Lesion	1 (50.0)	1 (50.0)
Q552 Examination of female genital tract under anaesthetic	2 (66.7)	1 (33.3)
S018 Other specified plastic excision of skin of head or neck	1 (50.0)	1 (50.0)
S022 Abdominolipectomy		1 (100.0)
S081 Curettage And Cauterisation Of Lesion Of Skin Of Head Or Neck		1 (100.0)
S083 Curettage Of Lesion Of Skin Of Head Or Neck		1 (100.0)
S151 Biopsy Of Lesion Of Skin Of Head Or Neck	52 (57.8)	38 (42.2)
S152 Biopsy Of Lesion Of Skin	2 (33.3)	4 (66.7)
T013 Excision Of Lesion Of Chest Wall	6 (50.0)	6 (50.0)
T071 Decortication Of Pleura		5 (100.0)
T072 Open Excision Of Lesion Of Pleura		2 (100.0)
T102 Endoscopic Pleurodesis Using Talc	3 (100.0)	
T111 Diagnostic Endoscopic Examination Of Pleura And Biopsy Of Lesion		1 (100.0)
T112 Diagnostic Endoscopic Excision Biopsy of Lesion Intrathoracic Organ	1 (100.0)	
T252 Primary repair of incisional hernia using insert of prosthetic material		1 (100.0)
T301 Reopening Of Abdomen And Re-Exploration Of Intra-abdominal Operation Site	1 (50.0)	1 (50.0)
T303 Reopening Of Abdomen	1 (50.0)	1 (50.0)
T304 Opening Of Abdomen And Exploration Of Groin		4 (100.0)
T309 Laparotomy (exploratory) open and close		1 (100.0)
T319 Unspecified other operations on anterior abdominal wall	1 (100.0)	
T331 Open Excision Of Lesion Of Peritoneum	9 (50.0)	9 (50.0)
T332 Open Destruction Of Lesion Of Peritoneum	1 (33.3)	2 (66.7)
T361 Omentectomy	2 (40.0)	3 (60.0)
T362 Excision Of Lesion Of Omentum	1 (10.0)	9 (90.0)
T364 Biopsy Of Lesion Of Omentum	3 (37.5)	5 (62.5)
T371 Excision Of Lesion Of Mesentery Of Small Intestine		1 (100.0)
T373 Biopsy Of Lesion Of Mesentery Of Small Intestine	1 (100.0)	
T381 Excision Of Lesion Of Mesentery Of Colon	1 (50.0)	1 (50.0)
T383 Biopsy Of Lesion Of Mesentery Of Colon	1 (50.0)	1 (50.0)
T391 Excision Of Lesion Of Posterior Peritoneum	11 (32.4)	23 (67.6)
T393 Biopsy Of Lesion Of Posterior Peritoneum	7 (70.0)	3 (30.0)
T421 Endoscopic Resection Of Lesion Of Peritoneum		3 (100.0)
T423 Endoscopic Division Of Adhesions Of Peritoneum	1 (50.0)	1 (50.0)
T425 Endoscopic Excision Of Peritoneum		2 (100.0)
T431 Diagnostic Endoscopic Examination and Biopsy Of Lesion Of Peritoneum	2 (25.0)	6 (75.0)
T432 Diag.endo.exam/Peritoneum/Biopsy/Lesion Intra-Abdominal Organ	1 (25.0)	3 (75.0)
T434 Diagnostic Endoscopic Ultrasound Examination Of Peritoneum and Biopsy		1 (100.0)
T482 Introduction Of Cytotoxic Substance Into Peritoneal Cavity	6 (35.3)	11 (64.7)
T512 Excision Of Fascia Of Pelvis		2 (100.0)
T531 Excision Of Lesion Of Fascia		3 (100.0)
T652 Excision Of Lesion Of Tendon		1 (100.0)
T772 Wide Excision Of Muscle	13 (40.6)	19 (59.4)
T851 Block Dissection Of Cervical Lymph Nodes	31 (25.4)	91 (74.6)
T852 Block Dissection Of Axillary Lymph Nodes	20 (36.4)	35 (63.6)
T853 Block Dissection Of Mediastinal Lymph Nodes	1 (33.3)	2 (66.7)
T854 Block Dissection Of Para-Aortic Lymph Nodes	4 (23.5)	13 (76.5)

T855 Block Dissection Of Inguinal Lymph Nodes	3 (20.0)	12 (80.0)
T856 Block Dissection Of Pelvic Lymph Nodes	2 (40.0)	3 (60.0)
T861 Sampling Of Cervical Lymph Nodes		3 (100.0)
T862 Sampling Of Axillary Lymph Nodes	8 (50.0)	8 (50.0)
T863 Sampling of supraclavicular lymph nodes		1 (100.0)
T866 Sampling Of Para-Aortic Lymph Nodes		3 (100.0)
T872 Excision Or Biopsy Of Cervical Lymph Node		9 (100.0)
T873 Excision Or Biopsy Of Axillary Lymph Node	6 (26.1)	15 (73.9)
T874 Excision Or Biopsy Of Mediastinal Lymph Node		4 (100.0)
T875 Excision Or Biopsy Of Para-Aortic Lymph Node		4 (100.0)
T876 Excision Or Biopsy Of Porta Hepatis Lymph Node	1 (50.0)	1 (50.0)
T877 Excision Or Biopsy Of Inguinal Lymph Node	1 (50.0)	1 (50.0)
T878 Other specified excision or biopsy of lymph node	1 (100.0)	
T882 Drainage of lesion of axillary lymph node		1 (100.0)
T911 Biopsy Of Sentinel Lymph Node	3 (10.0)	27 (90.0)
T926 Excision Of Lymphoedematous Tissue		1 (100.0)
T962 Excision Of Lesion Of Soft Tissue	69 (33.8)	135 (66.2)
T966 Biopsy Of Soft Tissue		1 (100.0)
V032 Reopening Of Cranium And Re-Exploration Of Intracranial Operation Site		4 (100.0)
V037 Decompressive Craniectomy	1 (12.5)	7 (87.5)
V068 Other specified excision of maxilla		7 (100.0)
V071 Extensive Excision Of Bone Of Face		6 (100.0)
V072 Partial Excision Of Bone Of Face	1 (20.0)	4 (80.0)
V073 Excision Of Lesion Of Bone Of Face		6 (100.0)
V074 Excision Of Lesion Of Infratemporal Fossa	1 (20.0)	4 (80.0)
V128 Other specified operations on bones of skull	1 (100.0)	
V141 Hemimandibulectomy	4 (10.5)	34 (89.5)
V142 Extensive Excision Of Mandible	1 (2.9)	34 (97.1)
V143 Partial Excision Of Mandible	8 (22.9)	27 (77.1)
V144 Excision Of Lesion Of Mandible	4 (10.8)	33 (89.2)
V191 Reconstruction Of Mandible		3 (100.0)
V194 Biopsy Of Lesion Of Mandible		3 (100.0)
V421 Excision of rib hump		1 (100.0)
V431 Excision Of Lesion Of Cervical Vertebra		1 (100.0)
V432 Excision Of Lesion Of Thoracic Vertebra	1 (50.0)	1 (50.0)
V433 Excision Of Lesion Of Lumbar Vertebra	1 (33.3)	2 (66.7)
W062 Total Excision Of Rib	1 (50.0)	1 (50.0)
W065 Total Excision Of Bone Of Foot		1 (100.0)
W067 Total Excision Of Pelvic Bones		2 (100.0)
W088 Other specified other excision of bone	6 (42.9)	8 (57.1)
W091 Excision Of Lesion Of Bone		7 (100.0)
W092 Curettage Of Lesion Of Bone And Graft Hfq		1 (100.0)
W095 Curettage Of Tumour Of Bone And Graft		2 (100.0)
W096 Curettage Of Tumour Of Bone	1 (50.0)	1 (50.0)
W097 Excision Of Tumour Of Bone	10 (58.8)	7 (41.2)
X071 Forequarter Amputation	1 (50.0)	1 (50.0)
X073 Amputation Of Arm Above Elbow	1 (50.0)	1 (50.0)
X075 Amputation Of Arm Through Forearm		1 (100.0)
X091 Hindquarter Amputation	3 (75.0)	1 (25.0)
X092 Disarticulation of hip		1 (100.0)
X093 Amputation Of Leg Above Knee	1 (16.7)	5 (83.3)
X095 Amputation Of Leg Below Knee		4 (100.0)
X104 Amputation Through Metatarsal Bones		1 (100.0)
X141 Total Exenteration Of Pelvis	4 (25.0)	12 (75.0)
X142 Anterior Exenteration Of Pelvis	2 (22.2)	7 (77.8)
X143 Posterior Exenteration Of Pelvis	5 (50.0)	5 (50.0)
X144 Pelvic Side Wall Clearance	1 (100.0)	
X531 Excision Of Unspecified Organ	5 (62.5)	3 (37.5)
X532 Excision Of Lesion Of Unspecified Organ	4 (13.3)	26 (86.7)
Y052 Partial Excision Of Organ		2 (100.0)
Y063 Enucleation Of Lesion Of Organ	1 (50.0)	1 (50.0)
Y067 Radiofrequency Excision Of Lesion Of Organ Noc	4 (40.0)	6 (60.0)
Y081 Laser excision of organ NOC		2 (100.0)
Y201 Stereotactic Biopsy Of Lesion Of Organ Noc	3 (100.0)	
Y202 Stereotactic Biopsy Of Organ Noc		1 (100.0)
Y491 Median sternotomy approach	1 (100.0)	
Y502 Laparotomy approach	2 (11.1)	16 (88.9)
Y752 Laparoscopic approach to abdominal cavity	1 (16.7)	5 (83.3)

OPCS Classification of Interventions and Procedures (OPCS-4) codes (three digit codes) used to classify included procedures according to UK industry standard codes. Percentages calculated as a proportion of row total.

Supplementary table 3. Factors associated with postoperative pulmonary complications after elective surgery. Model summary presented in forest plot in Figure 2.

Factor	Level	Outcome		Univariable model (Odds ratio, 95% credible interval)	Multivariable model (Odds ratio, 95% credible interval)
		None (N=8592)	Pulmonary Complications (N=379)		
Age	<50 years	1594 (98.8)	20 (1.2)	-	-
	50-59 years	1868 (97.4)	50 (2.6)	2.05 (1.20 to 3.51)	1.44 (0.86 to 2.52)
	60-69 years	2379 (95.4)	115 (4.6)	3.69 (2.30 to 6.03)	1.90 (1.18 to 3.17)
	70-79 years	2054 (93.5)	143 (6.5)	5.25 (3.33 to 8.65)	2.11 (1.30 to 3.47)
	≥80 years	697 (93.2)	51 (6.8)	5.39 (3.21 to 9.19)	1.96 (1.11 to 3.52)
Sex	Female	5331 (97.8)	119 (2.2)	-	-
	Male	3261 (92.6)	260 (7.4)	3.48 (2.79 to 4.38)	1.74 (1.37 to 2.25)
BMI	Normal	3362 (96.2)	134 (3.8)	-	-
	Overweight	2735 (96.0)	115 (4.0)	1.08 (0.83 to 1.38)	1.02 (0.78 to 1.33)
	Obese	1791 (95.5)	84 (4.5)	1.20 (0.91 to 1.59)	1.06 (0.79 to 1.43)
	Underweight	201 (95.3)	10 (4.7)	1.21 (0.59 to 2.25)	1.10 (0.51 to 2.20)
	Missing	503 (93.3)	36 (6.7)	1.56 (1.02 to 2.31)	1.69 (1.10 to 2.52)
ASA Grade	Grade 1-2	6299 (97.1)	190 (2.9)	-	-
	Grade 3-5	2293 (92.4)	189 (7.6)	2.87 (2.31 to 3.56)	1.36 (1.04 to 1.77)
Specialty	Colorectal	2122 (94.1)	132 (5.9)	-	-
	Breast	2071 (99.6)	8 (0.4)	0.06 (0.03 to 0.12)	0.30 (0.12 to 0.71)
	Gynaecological	1062 (98.2)	20 (1.8)	0.29 (0.17 to 0.46)	0.61 (0.37 to 1.01)
	Head or neck	1085 (96.4)	41 (3.6)	0.64 (0.44 to 0.93)	1.35 (0.75 to 2.34)
	Hepatopancreatobilary	618 (92.5)	50 (7.5)	1.34 (0.94 to 1.90)	1.40 (0.97 to 2.00)
	Intracranial	151 (98.7)	2 (1.3)	0.19 (0.03 to 0.69)	0.33 (0.04 to 1.42)
	Thoracic	497 (92.7)	39 (7.3)	1.08 (0.73 to 1.62)	1.05 (0.70 to 1.53)
	Oesophagogastric	317 (83.2)	64 (16.8)	3.44 (2.43 to 4.80)	3.45 (2.39 to 4.91)
	Sarcoma	250 (96.9)	8 (3.1)	0.52 (0.23 to 1.07)	0.99 (0.41 to 2.07)
	Urological	419 (96.5)	15 (3.5)	0.54 (0.29 to 0.94)	0.64 (0.36 to 1.12)
ECOG Performance Score	0	5550 (97.5)	145 (2.5)	-	-
	1-2	2907 (93.0)	219 (7.0)	2.81 (2.27 to 3.51)	1.67 (1.28 to 2.15)
	3-4	135 (90.0)	15 (10.0)	4.07 (2.24 to 7.07)	2.17 (1.10 to 4.02)
Current smoker	No	7670 (96.0)	316 (4.0)	-	-
	Yes	922 (93.6)	63 (6.4)	1.56 (1.17 to 2.05)	1.41 (1.03 to 1.89)
Pre-existing respiratory condition	No	7698 (96.2)	303 (3.8)	-	-
	Yes	894 (92.2)	76 (7.8)	1.96 (1.51 to 2.51)	1.35 (1.00 to 1.80)
RCRI	0	2789 (98.9)	32 (1.1)	-	-
	1	4319 (95.2)	217 (4.8)	4.10 (2.84 to 6.06)	1.69 (0.91 to 3.02)
	2	1218 (93.2)	89 (6.8)	6.20 (4.14 to 9.53)	1.72 (0.88 to 3.30)
	≥3	266 (86.6)	41 (13.4)	12.78 (7.71 to 21.14)	2.98 (1.43 to 6.28)
Operation grade	Minor	2025 (98.7)	26 (1.3)	-	-
	Major	6567 (94.9)	353 (5.1)	4.16 (2.87 to 6.36)	2.11 (1.33 to 3.43)
Disease stage	Early stage	6171 (96.6)	217 (3.4)	-	-
	Advanced stage	2421 (93.7)	162 (6.3)	1.86 (1.52 to 2.28)	1.43 (1.14 to 1.80)
Preoperative testing	Not tested	6240 (95.6)	284 (4.4)	-	-
	Tested	2352 (96.1)	95 (3.9)	0.92 (0.69 to 1.19)	0.92 (0.70 to 1.20)
Hospital type	No defined pathway	6198 (95.0)	324 (5.0)	-	-
	COVID-19 free surgical pathway	2394 (97.8)	55 (2.2)	0.49 (0.36 to 0.66)	0.62 (0.44 to 0.86)
Community SARS-Cov-2 risk	Low	7511 (95.8)	328 (4.2)	-	-
	Moderate or high	1081 (95.5)	51 (4.5)	1.03 (0.71 to 1.50)	1.42 (0.96 to 2.15)

)ata included from 8971 patients with complete data. COVID-19=Coronavirus disease 2019. ASA=American Society of Anaesthesiologists. RCRI= Revised Cardiac Risk Index. :COG=Eastern Cooperative Oncology Group. Please see *Appendix C* for full definitions. Percentages calculated as a proportion of row total. R statistic <1.1 for all variables in ıe model (Supplementary Table 9). Model convergence and fit shown in Supplementary Figure 1 and 2 respectively. Area under the Receiver Operating Characteristic curve ɔr model: 0.82 (excellent discrimination).

Supplementary table 4. Sensitivity analysis of factors associated with postoperative pulmonary complications after elective surgery in low risk patient only (ASA grade 1-2).

Factor	Level	Outcome		Univariable model (Odds ratio, 95% credible interval)	Multivariable model (Odds ratio, 95% credible interval)
		None (N=6299)	Pulmonary Complications (N=190)		
Age	<50 years	1450 (99.0)	14 (1.0)	-	-
	50-59 years	1560 (97.9)	34 (2.1)	2.23 (1.21 to 4.28)	1.56 (0.85 to 3.06)
	60-69 years	1744 (96.4)	66 (3.6)	3.87 (2.17 to 7.19)	2.16 (1.20 to 4.11)
	70-79 years	1226 (95.1)	63 (4.9)	5.29 (2.98 to 9.90)	2.49 (1.36 to 4.81)
	≥80 years	319 (96.1)	13 (3.9)	3.98 (1.85 to 8.72)	1.55 (0.70 to 3.55)
Sex	Female	4208 (98.6)	61 (1.4)	-	-
	Male	2091 (94.2)	129 (5.8)	4.16 (3.03 to 5.65)	2.76 (2.01 to 3.86)
BMI	Normal	2631 (97.4)	71 (2.6)	-	-
	Overweight	2022 (97.1)	61 (2.9)	1.10 (0.78 to 1.55)	0.90 (0.64 to 1.29)
	Obese	1107 (96.5)	40 (3.5)	1.30 (0.84 to 1.96)	1.08 (0.69 to 1.67)
	Underweight	138 (97.9)	3 (2.1)	0.67 (0.17 to 1.97)	0.70 (0.18 to 2.26)
	Missing	401 (96.4)	15 (3.6)	1.05 (0.58 to 1.85)	1.12 (0.58 to 2.01)
ECOG Performance Score	0	4759 (97.9)	104 (2.1)	-	-
	1-2	1510 (94.7)	84 (5.3)	2.53 (1.84 to 3.41)	1.77 (1.29 to 2.46)
	3-4	30 (93.8)	2 (6.2)	2.61 (0.39 to 10.70)	2.24 (0.28 to 9.95)
Current smoker	No	5657 (97.2)	160 (2.8)	-	-
	Yes	642 (95.5)	30 (4.5)	1.57 (1.05 to 2.31)	1.44 (0.91 to 2.25)
Pre-existing respiratory condition	No	5846 (97.2)	169 (2.8)	-	-
	Yes	453 (95.6)	21 (4.4)	1.35 (0.82 to 2.16)	1.03 (0.61 to 1.66)
RCRI	0	2429 (99.1)	21 (0.9)	-	-
	1	3273 (96.3)	126 (3.7)	4.35 (2.78 to 7.03)	2.28 (1.41 to 3.82)
	2	557 (94.4)	33 (5.6)	6.78 (3.94 to 11.93)	2.56 (1.41 to 4.79)
	≥3	40 (80.0)	10 (20.0)	26.73 (11.24 to 61.50)	9.53 (3.73 to 23.27)
Operation grade	Minor	1578 (98.9)	17 (1.1)	-	-
	Major	4721 (96.5)	173 (3.5)	3.51 (2.14 to 6.08)	1.71 (1.01 to 3.03)
Disease stage	Early stage	4642 (97.6)	116 (2.4)	-	-
	Advanced stage	1657 (95.7)	74 (4.3)	1.75 (1.29 to 2.36)	1.47 (1.08 to 1.98)
Preoperative testing	Not tested	4571 (97.0)	139 (3.0)		
	Tested	1728 (97.1)	51 (2.9)	1.09 (0.77 to 1.53)	1.03 (0.73 to 1.47)
Hospital type	No defined pathway	4393 (96.5)	160 (3.5)	-	-
	COVID-19 free surgical pathway	1906 (98.5)	30 (1.5)	0.48 (0.31 to 0.74)	0.58 (0.36 to 0.93)
Community SARS-Cov-2 risk	Low	5465 (97.1)	165 (2.9)	-	-
	High	834 (97.1)	25 (2.9)	1.17 (0.68 to 1.99)	1.54 (0.86 to 2.66)

Data included from 6489 patients with complete data. COVID-19=Coronavirus disease 2019. ASA=American Society of Anaesthesiologists. RCRI= Revised Cardiac Risk Index. ECOG=Eastern Cooperative Oncology Group. Please see *Appendix C* for full definitions. Percentages calculated as a proportion of row total. Odds ratios are presented with 95 percent credible intervals. R statistic <1.1 for all variables in the model. Area under the Receiver Operating Characteristic curve for model: 0.81 (excellent discrimination).

Supplementary table 5. Balance of risk factors across patients in COVID-19 free surgical pathways and hospitals with no defined COVID-19 free pathway in propensity score matched data.

Factor	Levels	COVID-19 free surgical pathway N=2449	No defined pathway N=2449	P-value
Age, n (%)	<50 years	550 (22.5)	569 (23.2)	0.757
	50-59 years	560 (22.9)	582 (23.8)	
	60-69 years	630 (25.7)	628 (25.6)	
	70-79 years	550 (22.5)	517 (21.1)	
	≥80 years	159 (6.5)	153 (6.2)	
Sex, n (%)	Female	1716 (70.1)	1747 (71.3)	0.346
	Male	733 (29.9)	702 (28.7)	
ASA Grade, n (%)	ASA grade 1-2	1936 (79.1)	1938 (79.1)	0.972
	ASA grade 3-5	513 (20.9)	511 (20.9)	
ECOG Performance Score, n (%)	0	1642 (67.0)	1575 (64.3)	0.128
	1-2	771 (31.5)	837 (34.2)	
	3-4	36 (1.5)	37 (1.5)	
Operation grade, n (%)	Minor	593 (24.2)	587 (24.0)	0.867
	Major	1856 (75.8)	1862 (76.0)	
Preoperative testing, n (%)	Not tested	1481 (60.5)	1541 (62.9)	0.083
	Tested	968 (39.5)	908 (37.1)	
Community SARS-Cov-2 risk, n (%)	Low	1921 (78.4)	1969 (80.4)	0.097
	Moderate or high	528 (21.6)	480 (19.6)	

COVID-19=Coronavirus disease 2019. ASA=American Society of Anaesthesiologists. RCRI= Revised Cardiac Risk Index. ECOG=Eastern Cooperative Oncology Group. Please see *Appendix C* for full definitions. Percentages calculated as a proportion of column total.

Supplementary table 6. Factors associated with postoperative pulmonary complications after elective cancer surgery in propensity matched data.

Factor	Level	Outcome		Univariable model (Odds ratio, 95% credible interval)	Multivariable model (Odds ratio, 95% credible interval)
		None (N=4745)	Pulmonary Complications (N=153)		
Age	<50 years	1108 (23.4)	11 (7.2)		-
	50-59 years	1119 (23.6)	23 (15.0)	2.09 (1.02 to 4.60)	1.55 (0.74 to 3.44)
	60-69 years	1209 (25.5)	49 (32.0)	4.10 (2.15 to 8.38)	2.07 (1.03 to 4.53)
	70-79 years	1015 (21.4)	52 (34.0)	5.12 (2.76 to 10.21)	2.03 (1.01 to 4.47)
	≥80 years	294 (6.2)	18 (11.8)	6.20 (2.90 to 13.73)	1.99 (0.86 to 4.87)
Sex	Female	3401 (71.7)	62 (40.5)		-
	Male	1344 (28.3)	91 (59.5)	3.79 (2.72 to 5.34)	1.79 (1.24 to 2.66)
BMI	Normal	1977 (41.7)	56 (36.6)		-
	Overweight	1515 (31.9)	46 (30.1)	1.09 (0.72 to 1.64)	1.02 (0.69 to 1.52)
	Obese	893 (18.8)	32 (20.9)	1.31 (0.83 to 2.02)	1.16 (0.72 to 1.84)
	Underweight	109 (2.3)	4 (2.6)	1.08 (0.32 to 3.00)	1.02 (0.28 to 2.90)
	Missing	251 (5.3)	15 (9.8)	1.91 (1.01 to 3.48)	2.26 (1.13 to 4.27)
ASA Grade	Grade 1-2	3787 (79.8)	87 (56.9)		-
	Grade 3-5	958 (20.2)	66 (43.1)	2.91 (2.06 to 4.07)	1.17 (0.76 to 1.80)
Specialty	Colorectal	984 (20.7)	49 (32.0)		-
	Breast	1447 (30.5)	6 (3.9)	0.08 (0.03 to 0.18)	0.31 (0.09 to 0.94)
	Gynaecological	641 (13.5)	8 (5.2)	0.23 (0.10 to 0.47)	0.46 (0.19 to 1.01)
	Head or neck	550 (11.6)	21 (13.7)	0.79 (0.46 to 1.33)	1.43 (0.61 to 3.27)
	Hepatopancreatobilary	304 (6.4)	27 (17.6)	1.78 (1.09 to 2.95)	2.01 (1.16 to 3.42)
	Intracranial	70 (1.5)	1 (0.7)	0.18 (0.01 to 1.35)	0.43 (0.02 to 3.82)
	Thoracic	270 (5.7)	15 (9.8)	0.95 (0.50 to 1.80)	1.02 (0.50 to 1.92)
	Oesophagogastric	146 (3.1)	18 (11.8)	2.67 (1.46 to 4.72)	2.57 (1.38 to 4.68)
	Sarcoma	169 (3.6)	4 (2.6)	0.43 (0.13 to 1.12)	0.71 (0.19 to 2.11)
	Urological	164 (3.5)	4 (2.6)	0.42 (0.12 to 1.11)	0.47 (0.13 to 1.31)
ECOG Performance Score	0	3159 (66.6)	58 (37.9)		-
	1-2	1518 (32.0)	90 (58.8)	3.18 (2.24 to 4.47)	1.83 (1.25 to 2.68)
	3-4	68 (1.4)	5 (3.3)	3.52 (1.25 to 8.70)	1.70 (0.57 to 4.69)
Current smoker	No	4248 (89.5)	128 (83.7)		-
	Yes	497 (10.5)	25 (16.3)	1.62 (1.02 to 2.49)	1.33 (0.81 to 2.14)
Pre-existing respiratory condition	No	4309 (90.8)	125 (81.7)		-
	Yes	436 (9.2)	28 (18.3)	2.09 (1.31 to 3.22)	1.44 (0.89 to 2.26)
RCRI	0	1793 (37.8)	19 (12.4)		-
	1	2300 (48.5)	90 (58.8)	3.53 (2.17 to 6.03)	1.65 (0.70 to 3.84)
	2	551 (11.6)	29 (19.0)	4.88 (2.72 to 9.10)	1.50 (0.57 to 3.73)
	≥3	101 (2.1)	15 (9.8)	13.16 (6.36 to 27.49)	3.10 (1.05 to 8.77)
Operation grade	Minor	1165 (24.6)	15 (9.8)		-
	Major	3580 (75.4)	138 (90.2)	3.03 (1.80 to 5.34)	1.54 (0.79 to 3.16)
Disease stage	Early stage	3498 (73.7)	93 (60.8)		-
	Advanced stage	1247 (26.3)	60 (39.2)	1.79 (1.28 to 2.51)	1.39 (0.97 to 1.96)
Preoperative testing	Not tested	2930 (61.7)	92 (60.1)		-
	Tested	1815 (38.3)	61 (39.9)	1.06 (0.74 to 1.51)	0.94 (0.64 to 1.37)
Hospital type	No defined pathway	2351 (49.5)	98 (64.1)		-
	COVID-19 free surgical pathway	2394 (50.5)	55 (35.9)	0.67 (0.47 to 0.96)	0.65 (0.44 to 0.96)
SARS-Cov-2 risk area	Low	3772 (79.5)	118 (77.1)		-
	High	973 (20.5)	35 (22.9)	0.87 (0.52 to 1.39)	1.05 (0.63 to 1.77)

Data included from 2449 patients in a COVID-19 free surgical pathway propensity score matched with 2449 patients with no defined pathway (n=4898). COVID-19=Coronavirus disease 2019. ASA=American Society of Anaesthesiologists. RCRI= Revised Cardiac Risk Index. ECOG=Eastern Cooperative Oncology Group. Please see *Appendix C* for full definitions. Percentages calculated as a proportion of row total. R statistic <1.1 for all variables in the model. Area under the Receiver Operating Characteristic curve for model: 0.81 (excellent discrimination).

Supplementary table 7. Sensitivity analysis of factors associated with postoperative pulmonary complications after elective surgery in patients with a negative preoperative SARS-CoV-2 test only. Model summary presented in forest plot in Figure 4.

Factor	Level	Outcome		Univariable model (Odds ratio, 95% credible interval)	Multivariable model (Odds ratio, 95% credible interval)
		None (N=2352)	Pulmonary Complications (N=95)		
Age	<50 years	393 (99.0)	4 (1.0)	-	-
	50-59 years	529 (97.8)	12 (2.2)	2.50 (0.85 to 8.67)	1.79 (0.58 to 6.27)
	60-69 years	645 (95.4)	31 (4.6)	5.43 (1.92 to 17.13)	3.26 (1.15 to 11.22)
	70-79 years	578 (94.4)	34 (5.6)	6.90 (2.52 to 22.11)	3.02 (1.00 to 10.98)
	≥80 years	207 (93.7)	14 (6.3)	8.71 (2.86 to 31.65)	3.63 (1.10 to 13.35)
Sex	Female	1424 (97.6)	35 (2.4)	-	-
	Male	928 (93.9)	60 (6.1)	2.67 (1.72 to 4.22)	1.74 (1.11 to 2.79)
BMI	Normal	992 (96.5)	36 (3.5)	-	-
	Overweight	816 (96.5)	30 (3.5)	0.95 (0.59 to 1.55)	0.79 (0.46 to 1.33)
	Obese	427 (95.1)	22 (4.9)	1.26 (0.73 to 2.16)	0.96 (0.51 to 1.75)
	Underweight	61 (95.3)	3 (4.7)	1.19 (0.28 to 3.90)	1.07 (0.22 to 3.72)
	Missing	56 (93.3)	4 (6.7)	1.34 (0.37 to 3.82)	1.12 (0.32 to 3.35)
ASA Grade	Grade 1-2	1728 (97.1)	51 (2.9)	-	-
	Grade 3-5	624 (93.4)	44 (6.6)	2.72 (1.75 to 4.29)	1.39 (0.84 to 2.29)
ECOG Performance Score	0	1458 (97.4)	39 (2.6)	-	-
	1-2	857 (94.0)	55 (6.0)	2.52 (1.65 to 3.80)	1.51 (0.93 to 2.47)
	3-4	37 (97.4)	1 (2.6)	0.62 (0.02 to 4.54)	0.28 (0.01 to 2.20)
Current smoker	No	2103 (96.2)	82 (3.8)	-	-
	Yes	249 (95.0)	13 (5.0)	1.31 (0.67 to 2.37)	1.19 (0.59 to 2.25)
Pre-existing respiratory condition	No	2123 (96.6)	75 (3.4)	-	-
	Yes	229 (92.0)	20 (8.0)	2.43 (1.40 to 4.04)	1.75 (0.95 to 3.08)
RCRI	0	682 (98.7)	9 (1.3)	-	-
	1	1268 (96.0)	53 (4.0)	3.34 (1.68 to 7.17)	2.25 (1.08 to 4.97)
	2	336 (93.3)	24 (6.7)	5.87 (2.76 to 13.53)	3.09 (1.34 to 7.51)
	≥3	66 (88.0)	9 (12.0)	11.90 (4.11 to 33.18)	4.60 (1.50 to 14.12)
Operation grade	Minor	511 (98.8)	6 (1.2)	-	-
	Major	1841 (95.4)	89 (4.6)	4.27 (1.94 to 10.85)	2.24 (0.92 to 6.33)
Disease stage	Early stage	1648 (96.9)	52 (3.1)	-	-
	Advanced stage	704 (94.2)	43 (5.8)	1.95 (1.29 to 2.91)	1.70 (1.09 to 2.65)
Hospital type	No defined pathway	1407 (95.1)	72 (4.9)	-	-
	COVID-19 free surgical pathway	945 (97.6)	23 (2.4)	0.47 (0.26 to 0.79)	0.52 (0.29 to 0.91)
Community SARS-Cov-2 risk	Low	1842 (95.7)	83 (4.3)	-	-
	High	510 (97.7)	12 (2.3)	0.61 (0.30 to 1.27)	0.98 (0.45 to 2.05)

Data included from 2447 patients with complete data. COVID-19=Coronavirus disease 2019. ASA=American Society of Anaesthesiologists. RCRI= Revised Cardiac Risk Index. ECOG=Eastern Cooperative Oncology Group. Please see *Appendix C* for full definitions. Percentages calculated as a proportion of row total. R statistic <1.1 for all variables in the model. Area under the Receiver Operating Characteristic curve for model: 0.80 (excellent discrimination).

Supplementary Table 8. Factors associated with SARS-CoV-2 infection after elective cancer surgery.

Factor	Level	Outcome		Univariable model (Odds ratio, 95% credible interval)	Multivariable model (Odds ratio, 95% credible interval)
		None (N=8683)	SARS CoV-2 (N=288)		
Age	<50 years	1584 (98.1)	30 (1.9)	-	-
	50-59 years	1879 (98.0)	39 (2.0)	1.07 (0.65 to 1.77)	0.80 (0.48 to 1.30)
	60-69 years	2407 (96.5)	87 (3.5)	1.96 (1.23 to 3.05)	1.18 (0.76 to 1.88)
	70-79 years	2101 (95.6)	96 (4.4)	2.44 (1.57 to 3.81)	1.30 (0.81 to 2.07)
	≥80 years	712 (95.2)	36 (4.8)	2.81 (1.67 to 4.74)	1.44 (0.82 to 2.55)
Sex	Female	5331 (97.8)	119 (2.2)	-	-
	Male	3352 (95.2)	169 (4.8)	2.52 (1.98 to 3.24)	1.50 (1.11 to 2.06)
BMI	Normal	3399 (97.2)	97 (2.8)	-	-
	Overweight	2766 (97.1)	84 (2.9)	1.07 (0.80 to 1.44)	1.00 (0.73 to 1.35)
	Obese	1819 (97.0)	56 (3.0)	1.12 (0.78 to 1.59)	0.99 (0.69 to 1.40)
	Underweight	205 (97.2)	6 (2.8)	1.09 (0.42 to 2.40)	1.16 (0.45 to 2.61)
	Missing	494 (91.7)	45 (8.3)	2.74 (1.87 to 4.01)	2.48 (1.66 to 3.61)
ASA Grade	Grade 1-2	6308 (97.2)	181 (2.8)	-	-
	Grade 3-5	2375 (95.7)	107 (4.3)	1.83 (1.41 to 2.39)	1.14 (0.83 to 1.52)
Specialty	Colorectal	2157 (95.7)	97 (4.3)	-	-
	Breast	2055 (98.8)	24 (1.2)	0.24 (0.15 to 0.38)	0.88 (0.43 to 1.79)
	Gynaecological	1057 (97.7)	25 (2.3)	0.42 (0.26 to 0.67)	0.68 (0.39 to 1.15)
	Head or neck	1097 (97.4)	29 (2.6)	0.66 (0.43 to 1.00)	1.26 (0.68 to 2.31)
	Hepatopancreatobilary	633 (94.8)	35 (5.2)	1.45 (0.97 to 2.14)	1.36 (0.87 to 2.06)
	Intracranial	147 (96.1)	6 (3.9)	0.96 (0.35 to 2.13)	1.95 (0.68 to 5.08)
	Thoracic	511 (95.3)	25 (4.7)	0.89 (0.56 to 1.38)	0.93 (0.57 to 1.49)
	Oesophagogastric	360 (94.5)	21 (5.5)	1.66 (1.00 to 2.67)	1.71 (1.01 to 2.88)
	Sarcoma	250 (96.9)	8 (3.1)	0.64 (0.27 to 1.36)	0.91 (0.37 to 1.99)
	Urological	416 (95.9)	18 (4.1)	0.91 (0.52 to 1.50)	1.00 (0.57 to 1.68)
ECOG Performance Score	0	5553 (97.5)	142 (2.5)	-	-
	1-2	2985 (95.5)	141 (4.5)	1.85 (1.43 to 2.39)	1.24 (0.93 to 1.63)
	3-4	145 (96.7)	5 (3.3)	0.81 (0.26 to 2.11)	0.36 (0.10 to 1.08)
Current smoker	No	7736 (96.9)	250 (3.1)	-	-
	Yes	947 (96.1)	38 (3.9)	1.19 (0.82 to 1.70)	1.17 (0.77 to 1.71)
Pre-existing respiratory condition	No	7758 (97.0)	243 (3.0)	-	-
	Yes	925 (95.4)	45 (4.6)	1.47 (1.05 to 2.04)	1.17 (0.80 to 1.69)
RCRI	0	2781 (98.6)	40 (1.4)	-	-
	1	4377 (96.5)	159 (3.5)	2.44 (1.72 to 3.50)	2.13 (1.19 to 3.78)
	2	1236 (94.6)	71 (5.4)	4.20 (2.80 to 6.30)	3.00 (1.56 to 5.79)
	≥3	289 (94.1)	18 (5.9)	4.40 (2.37 to 7.95)	2.60 (1.12 to 5.91)
Operation grade	Minor	2015 (98.2)	36 (1.8)	-	-
	Major	6668 (96.4)	252 (3.6)	2.12 (1.49 to 3.14)	1.32 (0.85 to 2.10)
Disease stage	Early stage	6207 (97.2)	181 (2.8)	-	-
	Advanced stage	2476 (95.9)	107 (4.1)	1.58 (1.24 to 2.02)	1.38 (1.06 to 1.79)
Preoperative testing	Not tested	6303 (96.6)	221 (3.4)	-	-
	Tested	2380 (97.3)	67 (2.7)	0.72 (0.52 to 0.97)	0.79 (0.57 to 1.08)
Hospital type	No defined pathway	6287 (96.4)	235 (3.6)	-	-
	COVID-19 free surgical pathway	2396 (97.8)	53 (2.2)	0.52 (0.37 to 0.73)	0.53 (0.36 to 0.76)
Community SARS-Cov-2 risk	Low	7621 (97.2)	218 (2.8)	-	-
	High	1062 (93.8)	70 (6.2)	2.26 (1.55 to 3.32)	3.03 (2.00 to 4.62)

Data included from 8971 patients with complete data. COVID-19=Coronavirus disease 2019. ASA=American Society of Anaesthesiologists. RCRI= Revised Cardiac Risk Index. ECOG=Eastern Cooperative Oncology Group. Please see *Appendix C* for full definitions. Percentages calculated as a proportion of row total. R statistic <1.1 for all variables in the model (Supplementary Table 9). Area under the Receiver Operating Characteristic curve for model: 0.80 (excellent discrimination).

Supplementary Table 9. Sensitivity analysis of factors associated with SARS-CoV-2 infection on nasopharyngeal swab after elective cancer surgery.

Factor	Level	Outcome		Univariable model (Odds ratio, 95% credible interval)	Multivariable model (Odds ratio, 95% credible interval)
		None (N=8724)	SARS CoV-2 (N=247)		
Age	<50 years	1589 (98.5)	25 (1.5)	-	-
	50-59 years	1884 (98.2)	34 (1.8)	1.08 (0.63 to 1.88)	0.84 (0.48 to 1.47)
	60-69 years	2422 (97.1)	72 (2.9)	1.86 (1.16 to 3.05)	1.15 (0.68 to 1.96)
	70-79 years	2112 (96.1)	85 (3.9)	2.44 (1.53 to 3.96)	1.36 (0.81 to 2.35)
	≥80 years	717 (95.9)	31 (4.1)	2.68 (1.54 to 4.68)	1.44 (0.77 to 2.73)
Sex	Female	5345 (98.1)	105 (1.9)	-	-
	Male	3379 (96.0)	142 (4.0)	2.35 (1.81 to 3.09)	1.50 (1.09 to 2.08)
BMI	Normal	3418 (97.8)	78 (2.2)	-	-
	Overweight	2777 (97.4)	73 (2.6)	1.17 (0.82 to 1.65)	1.10 (0.78 to 1.56)
	Obese	1821 (97.1)	54 (2.9)	1.38 (0.93 to 1.98)	1.23 (0.84 to 1.78)
	Underweight	206 (97.6)	5 (2.4)	1.14 (0.42 to 2.75)	1.28 (0.43 to 3.07)
	Missing	502 (93.1)	37 (6.9)	2.87 (1.87 to 4.32)	2.59 (1.68 to 3.98)
ASA Grade	Grade 1-2	6333 (97.6)	156 (2.4)	-	-
	Grade 3-5	2391 (96.3)	91 (3.7)	1.75 (1.33 to 2.32)	1.04 (0.75 to 1.44)
Specialty	Colorectal	2174 (96.5)	80 (3.5)	-	-
	Breast	2057 (98.9)	22 (1.1)	0.28 (0.16 to 0.47)	1.13 (0.50 to 2.38)
	Gynaecological	1059 (97.9)	23 (2.1)	0.49 (0.29 to 0.78)	0.78 (0.44 to 1.36)
	Head or neck	1101 (97.8)	25 (2.2)	0.69 (0.43 to 1.12)	1.42 (0.74 to 2.65)
	Hepatopancreatobilary	636 (95.2)	32 (4.8)	1.71 (1.09 to 2.60)	1.63 (1.04 to 2.58)
	Intracranial	148 (96.7)	5 (3.3)	0.92 (0.31 to 2.24)	1.84 (0.57 to 5.14)
	Thoracic	515 (96.1)	21 (3.9)	0.94 (0.57 to 1.53)	1.03 (0.59 to 1.71)
	Oesophagogastric	365 (95.8)	16 (4.2)	1.46 (0.80 to 2.53)	1.61 (0.89 to 2.82)
	Sarcoma	250 (96.9)	8 (3.1)	0.82 (0.34 to 1.72)	1.33 (0.53 to 3.02)
	Urological	419 (96.5)	15 (3.5)	0.93 (0.51 to 1.63)	1.05 (0.57 to 1.87)
ECOG Performance Score	0	5575 (97.9)	120 (2.1)	-	-
	1-2	3003 (96.1)	123 (3.9)	1.90 (1.46 to 2.48)	1.27 (0.94 to 1.72)
	3-4	146 (97.3)	4 (2.7)	0.70 (0.18 to 2.08)	0.33 (0.08 to 1.05)
Current smoker	No	7768 (97.3)	218 (2.7)	-	-
	Yes	956 (97.1)	29 (2.9)	1.03 (0.68 to 1.53)	1.01 (0.65 to 1.52)
Pre-existing respiratory condition	No	7792 (97.4)	209 (2.6)	-	-
	Yes	932 (96.1)	38 (3.9)	1.43 (1.01 to 2.06)	1.17 (0.79 to 1.71)
RCRI	0	2785 (98.7)	36 (1.3)	-	-
	1	4402 (97.0)	134 (3.0)	2.27 (1.57 to 3.33)	2.06 (1.11 to 3.84)
	2	1248 (95.5)	59 (4.5)	3.81 (2.48 to 5.93)	2.83 (1.39 to 5.55)
	≥3	289 (94.1)	18 (5.9)	4.75 (2.58 to 8.66)	3.00 (1.27 to 6.76)
Operation grade	Minor	2021 (98.5)	30 (1.5)	-	-
	Major	6703 (96.9)	217 (3.1)	2.19 (1.51 to 3.30)	1.55 (0.97 to 2.49)
Disease stage	Early stage	6230 (97.5)	158 (2.5)	-	-
	Advanced stage	2494 (96.6)	89 (3.4)	1.50 (1.15 to 1.97)	1.34 (0.99 to 1.78)
Preoperative testing	Not tested	6326 (97.0)	198 (3.0)	-	-
	Tested	2398 (98.0)	49 (2.0)	0.56 (0.39 to 0.79)	0.63 (0.43 to 0.91)
Hospital type	No defined pathway	6317 (96.9)	205 (3.1)	-	-
	COVID-19 free surgical pathway	2407 (98.3)	42 (1.7)	0.46 (0.30 to 0.69)	0.44 (0.28 to 0.68)
Community SARS-Cov-2 risk	Low	7657 (97.7)	182 (2.3)	-	-
	Moderate or high	1067 (94.3)	65 (5.7)	2.51 (1.66 to 3.86)	3.28 (2.13 to 5.04)

Data included from 8971 patients with complete data. COVID-19=Coronavirus disease 2019. ASA=American Society of Anaesthesiologists. RCRI= Revised Cardiac Risk Index. ECOG=Eastern Cooperative Oncology Group. Please see *Appendix C* for full definitions. Percentages calculated as a proportion of row total. R statistic <1.1 for all variables in the model. Area under the Receiver Operating Characteristic curve for model: 0.79 (good discrimination).

Supplementary table 10. Outcomes after elective surgery in COVID-19 free surgical pathways and hospitals with no defined pathway.

Factor	Levels	COVID-19 free surgical pathway (N=2481)	No defined pathway (N=6689)	Univariable model (Odds ratio, 95% credible interval)
SARS-CoV-2 infection	No	2428 (97.9)	6451 (96.4)	0.51 (0.36 to 0.72)
	Yes	53 (2.1)	238 (3.6)	
Pulmonary respiratory complications	No	2426 (97.8)	6360 (95.1)	0.48 (0.35 to 0.64)
	Yes	55 (2.2)	329 (4.9)	
	Pneumonia	46 (1.9)	288 (4.3)	
	ARDS	10 (0.4)	56 (0.8)	
	Non-invasive ventilation	5 (0.2)	10 (0.1)	
	Invasive ventilation	6 (0.2)	29 (0.4)	
Patient status	Alive	2448 (99.3)	6533 (98.3)	0.45 (0.25 to 0.78)
	Alive - remains admitted in hospital	28 (1.1)	137 (2.1)	
	Alive - transferred to another hospital	26 (1.1)	29 (0.4)	
	Alive - discharged to a rehabilitation centre	13 (0.5)	76 (1.1)	
	Alive - discharged home	2381 (96.6)	6291 (94.6)	
	Died	18 (0.7)	116 (1.7)	
	Died - on-table	2 (0.1)	2 (0.0)	
	Died - on days 0-7 after surgery	3 (0.1)	18 (0.3)	
	Died - on days 8-30 after surgery	13 (0.5)	96 (1.4)	
	(Missing)	15	40	
Critical care	No	1925 (78.8)	5010 (76.1)	0.94 (0.82 to 1.08)
	Yes	517 (21.2)	1570 (23.9)	
	Planned from theatre	480 (19.7)	1456 (22.1)	
	Unplanned from theatre	17 (0.7)	54 (0.8)	
	Unplanned from ward	20 (0.8)	60 (0.9)	
	(Missing)	39	109	
Length of stay	Median [IQR]	4.0 [6.0]	4.0 [6.0]	

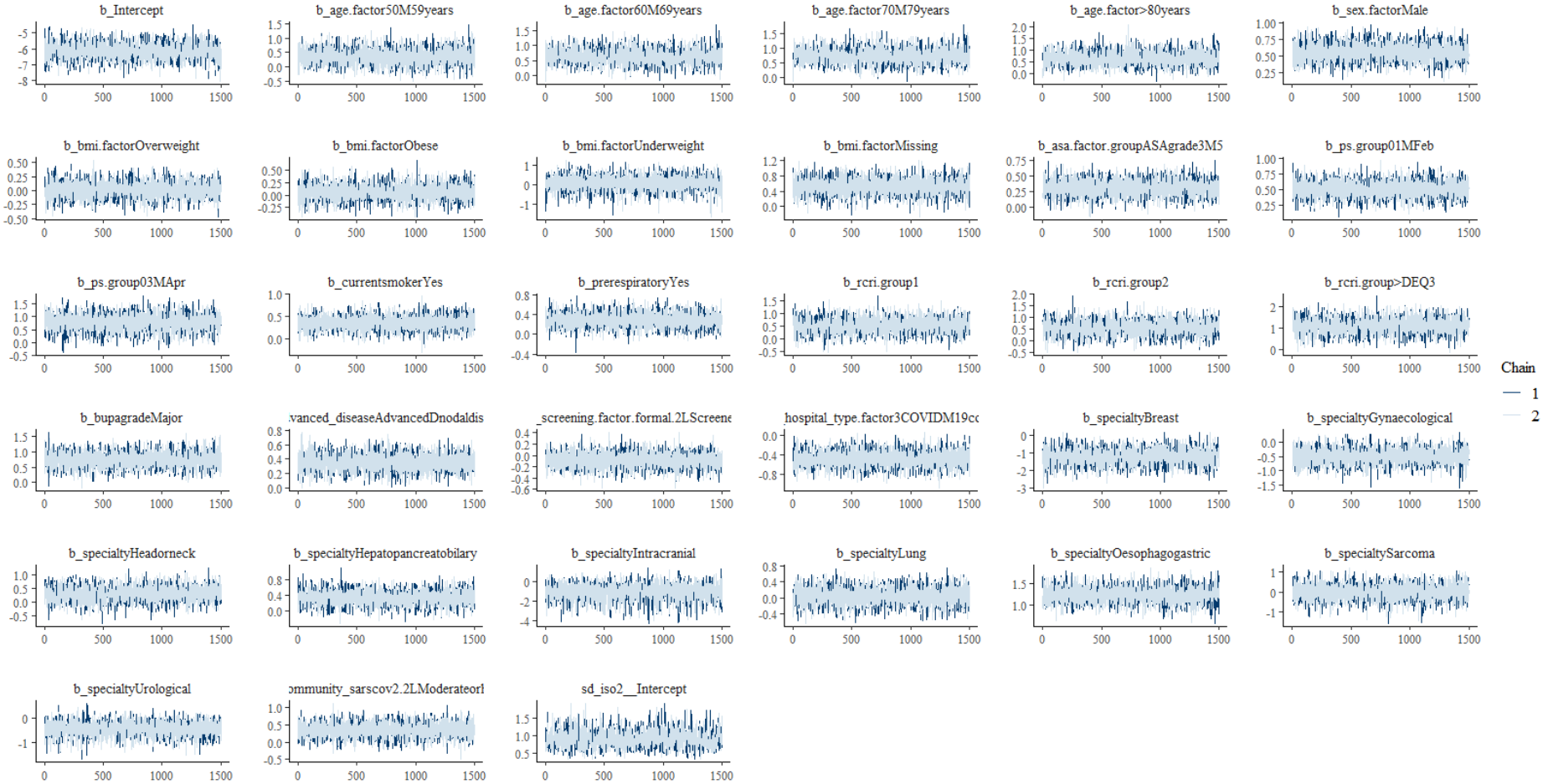
COVID-19=Coronavirus disease 2019. SD=standard deviation. Critical care defined as admission to a Level 2 (High Dependency Unit) or Level 3 (Intensive Care) bed. Percentages calculated as a proportion of column total. Estimates calculated using univariable Bayesian mixed effects logistic regression.

Supplementary table 11. Clinical impact of postoperative pulmonary complications after elective surgery during the COVID-19 pandemic.

Factor	Levels	No pulmonary Complications (n=8786)	Pulmonary Complication (N=385)	Univariable model (Odds ratio, 95% credible interval)
Patient status	Alive (all)	8663 (99.2)	318 (82.8)	25.64 (17.63 to 36.67)
	Alive - remains admitted in hospital	113 (1.3)	52 (13.5)	
	Alive - transferred to another hospital	45 (0.5)	10 (2.6)	
	Alive - discharged to a rehabilitation centre	67 (0.8)	22 (5.7)	
	Alive - discharged home	8438 (96.6)	234 (60.9)	
	Died (all)	68 (0.8)	66 (17.2)	
	Died - on-table	4 (0.0)	0 (0)	
	Died - on days 0-7 after surgery	12 (0.1)	9 (2.3)	
	Died - on days 8-30 after surgery	52 (0.6)	57 (14.8)	
	(Missing)	55	1	
SARS CoV-2	No	8625 (98.2)	255 (66.2)	29.78 (22.44 to 39.55)
	Yes	161 (1.8)	130 (33.8)	
Critical care	No	6789 (78.6)	146 (38.1)	6.48 (5.17 to 8.06)
	Yes	1850 (21.4)	237 (61.9)	
	Planned from theatre	1751 (20.3)	185 (48.3)	
	Unplanned from theatre	50 (0.6)	21 (5.5)	
	Unplanned from ward	49 (0.6)	31 (8.1)	
	(Missing)	147	2	
Length of stay	Median [IQR]	4.0 [6.0]	14.0 [16.0]	

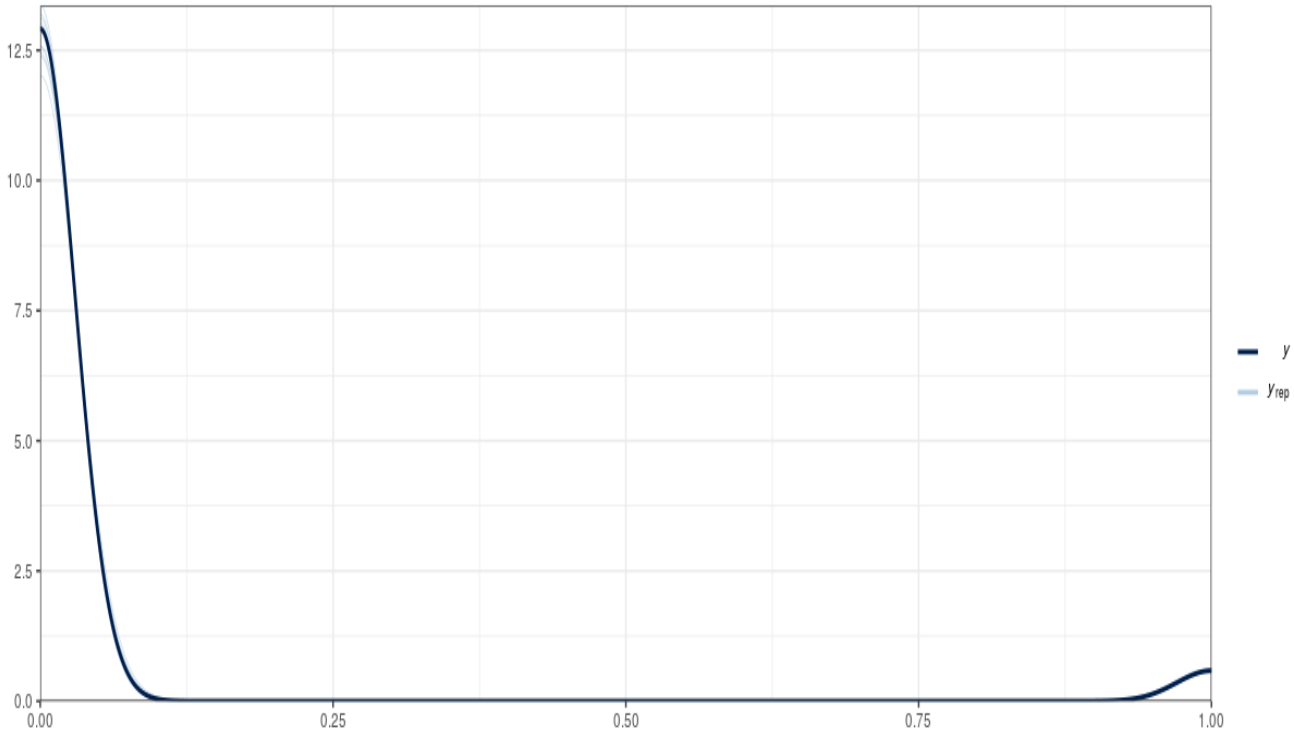
COVID-19=Coronavirus disease 2019. SD=standard deviation. Critical care defined as admission to a Level 2 (High Dependency Unit) or Level 3 (Intensive Care) bed. Percentages calculated as a proportion of column total. Estimates calculated using univariable Bayesian mixed effects logistic regression

Supplementary Figure 1. Trace plots for the fixed effects parameters in the primary model



A common check for the Markov Chain Monte Carlo sampler convergence is the trace plot. The plots above show the behaviour of the simulations (i.e., the chains) used to approximate the posterior distribution, where the x-axis represents the number of iterations and the y-axis the value of the parameter. To ensure the reliability of a finite set of samples, we routinely run several chains, i.e. we start the procedure at different random initial starting points and check whether the different chains have converged to stable values. In the figure above, the chains appear to be indistinguishable except for random noise and have converged to stable values. If the chains had not converged, the trajectories of the chains would be in different directions.

Supplementary Figure 2. Posterior predictive checks for the primary model of factors associated with postoperative pulmonary complications (summarised in Figure 2, and Supplementary Table 3)



Lines labelled ‘yrep’ refer to the posterior predictive values generated by the model, and the black solid line are the observed data.

Supplementary table 12. Posterior summary statistics for primary model of factors associated with postoperative pulmonary complications (summarised in Figure 2, and Supplementary Table 3).

Factor	Level	n_eff	Rhat	mean	mcse	Quantile estimate				
						2.50%	25%	50%	75%	97.50%
Age	50-59 years	2,185	1.001	0.4	0.006	-0.17	0.17	0.36	0.55	0.90
Age	60-69 years	2,181	1.001	0.6	0.006	0.13	0.43	0.60	0.79	1.12
Age	70-79 years	2,148	1.001	0.7	0.006	0.26	0.55	0.73	0.91	1.24
Age	≥80 years	2,256	1.000	0.7	0.006	0.13	0.48	0.67	0.88	1.26
Sex	Male	3,000	1.000	0.6	0.002	0.35	0.50	0.59	0.67	0.84
BMI	Overweight	3,000	1.000	0.0	0.002	-0.25	-0.07	0.02	0.11	0.28
BMI	Obese	3,000	0.999	0.0	0.003	-0.26	-0.06	0.05	0.16	0.34
BMI	Underweight	3,000	1.000	0.1	0.007	-0.68	-0.19	0.07	0.30	0.71
BMI	Missing	3,000	0.999	0.6	0.004	0.16	0.44	0.58	0.72	0.96
ASA Grade	3-5	3,000	1.000	0.4	0.002	0.10	0.27	0.35	0.44	0.60
ECOG Performance Score	1-2	3,000	0.999	0.5	0.002	0.24	0.39	0.48	0.56	0.72
ECOG Performance Score	3-4	3,000	1.000	0.7	0.006	0.03	0.50	0.73	0.94	1.33
Current smoker	Yes	3,000	1.000	0.4	0.003	0.04	0.25	0.35	0.46	0.65
Pre-existing respiratory condition	Yes	3,000	1.000	0.3	0.003	0.00	0.19	0.29	0.39	0.56
RCRI	1	1,922	1.000	0.5	0.007	-0.05	0.34	0.54	0.73	1.12
RCRI	2	1,976	1.000	0.5	0.007	-0.09	0.32	0.53	0.74	1.14
RCRI	≥3	2,053	1.000	1.1	0.008	0.39	0.82	1.06	1.29	1.75
Operation grade	Major	3,000	0.999	0.8	0.005	0.30	0.60	0.77	0.95	1.28
Disease stage	Advanced	3,000	1.000	0.4	0.002	0.14	0.28	0.36	0.43	0.58
Preoperative testing	Yes	3,000	1.000	-0.1	0.002	-0.36	-0.18	-0.10	-0.02	0.15
Hospital type	COVID-19 free surgical pathway	3,000	1.000	-0.5	0.003	-0.83	-0.61	-0.49	-0.38	-0.16
Specialty	Breast	3,000	1.000	-1.2	0.008	-2.14	-1.52	-1.21	-0.92	-0.39
Specialty	Gynaecological	3,000	1.000	-0.5	0.005	-1.03	-0.66	-0.48	-0.29	0.04
Specialty	Head or neck	2,265	1.000	0.3	0.006	-0.26	0.10	0.29	0.47	0.83
Specialty	Hepatopancreatobilary	3,000	0.999	0.3	0.003	-0.03	0.20	0.33	0.45	0.69
Specialty	Intracranial	3,000	1.000	-1.2	0.016	-3.06	-1.73	-1.12	-0.59	0.26
Specialty	Thoracic	3,000	0.999	0.1	0.004	-0.28	0.00	0.14	0.26	0.51
Specialty	Oesophagogastric	3,000	1.000	1.2	0.003	0.83	1.05	1.17	1.28	1.50
Specialty	Sarcoma	3,000	1.000	-0.1	0.007	-0.94	-0.36	-0.07	0.19	0.64
Specialty	Urological	3,000	1.000	-0.2	0.005	-0.71	-0.36	-0.17	0.00	0.32
SARS-Cov-2 risk area	Moderate or high	3,000	1.000	0.4	0.004	0.01	0.24	0.38	0.52	0.76

COVID-19=Coronavirus disease 2019. ASA=American Society of Anaesthesiologists. RCRI= Revised Cardiac Risk Index. ECOG=Eastern Cooperative Oncology Group. Please see *Appendix C* for full definitions. n_eff = effective sample size, Rhat = R statistic, mean = point estimate, mcse = standard error of the mean.

Appendix A: Collaborators (PubMed-citable)

Full list to be confirmed with final submission.

Appendix B. Processes to maximise case ascertainment and data completeness

Participating hospitals screened patients in order to ensure that all consecutive eligible patients were captured. Patients were identified from multidisciplinary team/tumour board meetings, operating theatre lists, ward handover lists, critical care records and other routinely collected health records.

Low case ascertainment might introduce bias, for example if patients who did not develop COVID-19 were missed. Site training, including written materials, webinars, infographics, specialty-specific social media training groups, and regular videoconferencing was used to support proactive data collection and eligible patient identification. No minimal case volume was imposed to include a broad sample of both high and low volume hospitals. There was an absolute requirement for all consecutive patients to be included.

Patients were followed up to 30 days from the day of surgery using electronic health records, ward handover lists, critical care records, emergency department readmission records, and outpatient telephone and/or in-person clinic appointments where this was performed as part of routine postoperative follow-up pathways.

Data were collected online and stored on a secure data server running the Research Electronic Data Capture (REDCap) web application[15]. All data were pseudonymized at source by each collaborating institution holding a secure, encrypted record of linked REDCap unique identification numbers and local medical record numbers. Site-specific data completeness summaries were distributed to site Principal Investigators at regular intervals to promote data completion and proactive identification of postoperative events.

Appendix C. Protocol definitions

Suspected cancer

Patients who were operated for suspected cancer but whose histology subsequently demonstrated pre-invasive lesions (e.g. high-grade dysplasia, carcinoma in situ) were included, but those with benign histology were excluded.

Elective surgery

Elective surgery was defined as an operation booked in advance of a planned admission to hospital.

Disease stage

To account for different tumour grading and staging systems across solid cancer types, disease status was classified as early stage (organ confined, non-nodal, non-metastatic, fully resectable) or advanced stage (growth beyond organ, nodal, metastatic with curative intent, debulking with life prolonging intent).

American Society of Anesthesiologists physical status classification (ASA)[38]

A validated system used to assess and communicate a patient's pre-anaesthesia medical co-morbidities. The classification system alone does not predict the perioperative risks but can be used with other factors (grade of surgery, ECOG performance status) to stratify risks of postoperative complications. The following grades were defined in the study protocol: Grade 1: Healthy person; Grade 2: Mild systemic disease; Grade 3: Severe systemic disease; Grade 4: Severe systemic disease that is a constant threat to life; Grade 5: A moribund person who is not expected to survive without the operation.

Revised Cardiac Risk Index (RCRI)[39, 40]

The RCRI represents a multifactorial approach to assessing the cardiac risk of non-cardiac surgery. It was calculated as a composite of procedural risk (intraperitoneal/intrathoracic versus other), history of ischemic heart disease, myocardial infarction, congestive heart failure, cerebrovascular disease, diabetes mellitus, and/or chronic kidney disease. This gave an attributable risk score from 0 (lowest risk) to 6 (highest risk).

Tumour type(s)	Early stage	Advanced stage
Colorectal **Oesophagogastric** **Head and neck** **Thoracic** **Urological** **Breast** **Sarcoma**	All of the following according to TNM classification[34]: T1 or T2 or T3 N0 M0	Any of the following according to TNM classification: T4 N1 or N2 or N3 M1
Hepatopancreatobiliary	All of the following according to National Comprehensive Cancer Network classification[35, 36]: Resectable Non-metastatic	Any of the following according to National Comprehensive Cancer Network classification: Borderline resectable or locally advanced Metastatic
Gynaecological	Any of the following according to International Federation of Gynecology and Obstetrics (FIGO) staging system[37]: Stage 0: Carcinoma in situ Stage I: Confined to organ of origin	Any of the following according to International Federation of Gynecology and Obstetrics (FIGO) staging system: Stage II: Invasion of surrounding organs/tissue Stage III: Spread to distant nodes Stage IV: Distant metastasis
Intracranial tumours	Histopathological classification: Low grade glioma Meningioma Vestibular schwannoma Pituitary adenoma	Histopathological classification: High grade glioma Primary CNS lymphoma Cerebral metastasis

Eastern Cooperative Oncology Group (ECOG) Risk Score[41]

The ECOG Scale of Performance Status describes a patient's level of functioning in terms of their ability to care for themself, daily activity, and physical ability (walking, working, etc). The performance status ranges from 0 (fully active without restriction) to 5 (dead), is freely available and widely validated.

GRADE	ECOG PERFORMANCE STATUS
0	Fully active, able to carry on all pre-disease performance without restriction
1	Restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature, e.g., light housework, office work
2	Ambulatory and capable of all selfcare but unable to carry out any work activities; up and about more than 50% of waking hours
3	Capable of only limited selfcare; confined to bed or chair more than 50% of waking hours
4	Completely disabled; cannot carry on any selfcare; totally confined to bed or chair
5	Dead

Postoperative pulmonary complications

The primary outcome measure was postoperative pulmonary complications defined as pneumonia, acute respiratory distress syndrome or unexpected ventilation within 30-days of surgery with the day of surgery as Day 0. This outcome was adapted from the Prevention of Respiratory Insufficiency after Surgical Management (PRISM) randomised controlled trial [19] and has previously been used to report postoperative pulmonary complications in SARS-CoV-2 infected patients [20].

Postoperative pneumonia

As recommended by international consensus on outcome measures for perioperative care, the US Centers for Disease Control (CDC) definition of pneumonia was used within 30 days after surgery, modified to accommodate limited availability of radiological facilities:

- Fever (>38°C) with no other recognised cause
- Leucopaenia (white cell count <4x109 L-1) or leucocytosis (white cell count >12x109 L-1)
- For adults >70 years old, altered mental status with no other recognised cause;

AND at least two of the following:

- New onset of purulent sputum or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements
- New onset or worsening cough, or dyspnoea, or tachypnoea
- Rales, crackles or bronchial breath sounds
- Worsening gas exchange (hypoxaemia, increased oxygen requirement).

Wherever possible, the diagnosis was confirmed with a chest radiograph. The following findings were considered to confirm pneumonia:

- New or progressive and persistent infiltrates
- Consolidation
- Cavitation

Unexpected post-operative ventilation

Unexpected postoperative ventilation was defined as either an episode of non-invasive ventilation, invasive ventilation, or extracorporeal membrane oxygenation after initial extubation following surgery, or unexpected failure to extubate following surgery.

Appendix D. Statistical analysis

Bayesian mixed-effect models

Models only included factors that occurred before the outcome of interest. For all models, non-informative priors were used with sensitivity analyses done on alternative priors and different chain initiation points or chain lengths. Model convergence was assessed using the R statistic. The ratio of between-chain variability and the within-chain variability should be approximately 1 when sampling from the posterior, so an R statistic of approximately 1 for each parameter is an indication that the model has converged. In addition, visual check of the trace plots for the fixed effects parameters gives an indication of the model convergence. Model fit was assessed by how well it matched the observed data using the posterior

predictive checks. If the predicted and observed data have similar distributions, it can be concluded that the model has a reasonable fit. For data with greater than 5% missingness, we pre-planned to add a separate category level for 'missing' data within the mixed-effects model to avoid loss of data. Model coefficients are presented as adjusted odds ratio (aOR) and 95% credible intervals (C.I).

Propensity score matched analyses

Propensity score matching (PSM) was used for sensitivity analysis. PSM involved building a binary logistic regression model to derive predictors of 30-day postoperative pulmonary complications by using a 3-step approach. Propensity scores were developed by including age, sex, ASA grade, operation grade, preoperative testing for SARS-CoV-2, ECOG performance score and community SARS-CoV-2 risk in a binary logistic regression model.

This logistic regression model was then combined with the PSMATCH2 command in Stata (Version 16.0; Statacorp, College Station, TX) to calculate propensity scores representing the estimated probability of 30-day postoperative pulmonary complications on each participant's characteristics. Participants in COVID-19 free surgical pathways were matched to participants with no defined pathway with the closest propensity score on a ratio of 1:1 using a nearest-neighbour algorithm with no replacement, and matching was restricted to within the common support region.

To ensure that the matching was effective, we checked the balance of covariates between the patients in COVID-19 free surgical pathways and with no defined pathway after the matching process.

Appendix E. Missing data summary

The overall missing data rate was 2.6% across all key risk variables included in the mixed-effects models, excluding Body Mass Index; this was not recorded in 6.9% (647/9409) of

patients, and so was entered as entered as a separate factor level in the mixed effects models in accordance with our statistical analysis plan. In the primary mixed effects models were no significant differences in the proportions of data missing from patients in COVID-19 free surgical pathway (2.7%) and with no defined pathway (2.5%) surgical units. One patient only was missing their operation location and 0.6% (61/9409) were missing postoperative mortality outcome data. No patients were missing data on postoperative SARS-CoV-2 status, postoperative pulmonary complications or community SARS-CoV-2 risk.

Appendix: References

1. Harris, P.A., et al., *Research electronic data capture (REDCap)--a metadata-driven methodology and workflow process for providing translational research informatics support.* J Biomed Inform, 2009. **42**(2): p. 377-81.
2. Amin, M.B., Edge, S.B, Gree, F.L. (et al) *AJCC Cancer Staging Manual 8th Edition.* New York: Springer, 2017.
3. Network, N.C.C., *NCCN Practice Clinical Guidelines in Oncology - Hepatobiliary Cancer Version 3.2020.* Jun 2020.
4. Network, N.C.C., *NCCN Practice Clinical Guidelines in Oncology - Pancreatic Adenocarcinoma Version 1.2020.* Nov 2019.
5. Bhatla, N., et al., *Revised FIGO staging for carcinoma of the cervix uteri.* Int J Gynaecol Obstet, 2019. **145**(1): p. 129-135.
6. American Society of Anesthesiologists. *ASA Physical Status Classification System* 2019 [cited 2020 June 6th; Standards and Guidelines.]. Available from: https://www.asahq.org/standards-and-guidelines/asa-physical-status-classification-system.
7. Fleisher, L.A., et al., *ACC/AHA 2006 guideline update on perioperative cardiovascular evaluation for noncardiac surgery: focused update on perioperative beta-blocker therapy: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Update the 2002 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery) developed in collaboration with the American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Rhythm Society, Society of Cardiovascular Anesthesiologists, Society for Cardiovascular Angiography and Interventions, and Society for Vascular Medicine and Biology.* J Am Coll Cardiol, 2006. **47**(11): p. 2343-55.
8. Lee, T.H., et al., *Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery.* Circulation, 1999. **100**(10): p. 1043-9.
9. Oken, M.M., et al., *Toxicity and response criteria of the Eastern Cooperative Oncology Group.* Am J Clin Oncol, 1982. **5**(6): p. 649-55.

STROBE Statement —Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	5
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	7
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (*b*) For matched studies, give matching criteria and number of exposed and unexposed	8-9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	9
Bias	9	Describe any efforts to address potential sources of bias	11, Appendix B, Appendix C
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding (*b*) Describe any methods used to examine subgroups and interactions (*c*) Explain how missing data were addressed (*d*) If applicable, explain how loss to follow-up was addressed (*e*) Describe any sensitivity analyses	11
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12-14

		(b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	 N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	12 12-14 N/A
Outcome data	15*	Report numbers of outcome events or summary measures over time	13-14
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	13-14, Tables 1, 2, 3 Tables 1,2,3
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	1

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

END